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Aggregate Resources Inventory of the Smooth Rock Falls Area Cochrane District Northern Ontario

By Staff of the Engineering and Terrain Geology Section
Ontario Geological Survey

1984

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Every possible effort is made to ensure the accuracy of the information contained in this report, but the Ministry of Natural Resources does not assume any liability for errors that may occur. Source references are included in the report and users may wish to verify critical information.

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ABSTRACT

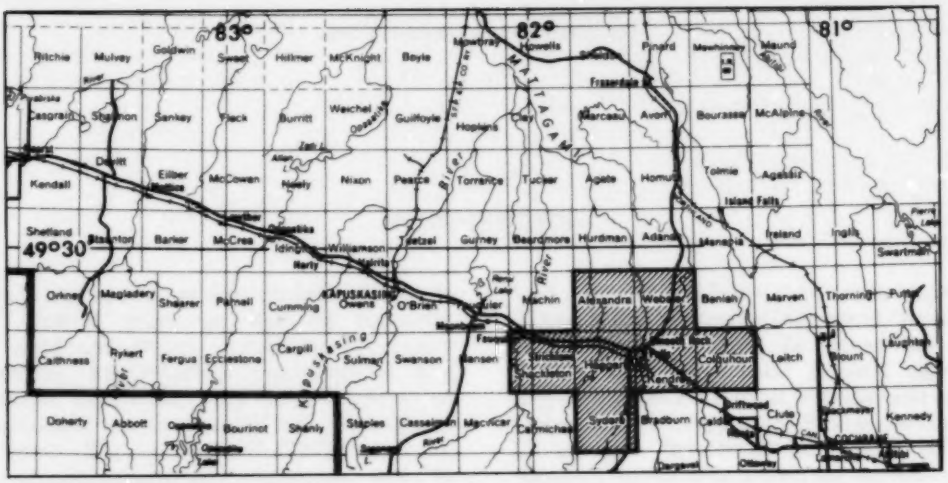

Figure 1 - Key Map Showing Location of the Smooth Rock Falls Area, Scale 1:1 584 000.

This report includes an inventory and evaluation of sand and gravel as well as bedrock resources for seven townships in the Smooth Rock Falls Area in the District of Cochrane. This report is based on data from previous studies and a detailed field assessment undertaken in the summer of 1981 by a two-man field party funded by the Ontario Ministry of Northern Affairs.

In the project area, five areas containing significant amounts of sand and gravel have been selected for possible resource protection. Selected Sand and Gravel Resource Areas occupy a total of 1680 acres (680 ha). An estimated 1300 acres (530 ha) are presently available for extraction, containing possible resources of approximately 89 million tons (81 million tonnes). The available portions of the selected areas represent 5 percent of the total area occupied by sand and gravel deposits in the study area, and 13 percent of the total resource tonnage.

Selected Sand and Gravel Resource Areas 1, 2, and 3 are esker segments extending from the northern end of Departure Lake in Haggart Township north into Alexandra Township. These areas are the most important natural aggregate deposits in the project area, containing an estimated 43 million tons (39 million tonnes) of sand and gravel. The aggregate in the deposits is suitable for a range of road-building and construction products.

Selected Sand and Gravel Resource Area 4 consists of three esker segments situated north of Greenwater Provincial Park in Colquhoun Township. The Area contains an estimated 6 million tons (5 million tonnes) of sand and gravel.

Selected Sand and Gravel Resource Area 5 consists of eight esker segments which form part of the same esker complex containing Resource Areas 1, 2, and 3. The segments extend from the southern end of Departure Lake into Sydere Township and contain an estimated 40 million tons (36 million tonnes) of sand and gravel.

The project area is underlain predominantly by migmatite-metasedimentary-metavolcanic complex rocks and felsic intrusive rocks of the Precambrian Shield. Drift cover is of variable thickness and bedrock exposure is infrequent and irregularly distributed. Both rock types are generally suitable for the production of crushed stone. Eight areas have been selected for possible resource protection containing possible resources of 1960 million tons (1780 million tonnes).

Selected Resource Areas are not intended to be permanent, single land use units which must be incorporated in an official planning document. They represent areas in which a major resource is known to exist. Such Resource Areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

AGGREGATE RESOURCES INVENTORY OF THE SMOOTH ROCK FALLS AREA[1]

BY
STAFF OF THE ENGINEERING
AND TERRAIN GEOLOGY SECTION

INTRODUCTION

Mineral aggregates, which include bedrock-derived crushed stone as well as naturally formed sand and gravel, constitute the major raw material in Ontario's road-building and construction industries. Very large amounts of these materials are used each year throughout the Province. For example, in 1981, the total tonnage of mineral aggregates extracted was 121 million tons (110 million tonnes), greater than that of any other metallic or nonmetallic commodity mined in the Province (Ontario Ministry of Natural Resources 1982).

Although mineral aggregate deposits are plentiful in Ontario, they are fixed-location, nonrenewable resources which can be exploited only in those areas where they occur. Mineral aggregates are characterized by their high bulk and low unit value so that the economic value of a deposit is a function of its proximity to a market area as well as its quality and size. The potential for extractive development is usually greatest in urban fringe areas where land use competition is extreme. For these reasons the availability of adequate resources for future development is now being threatened in some areas.

Comprehensive planning and resource management strategies are required to make the best use of available resources, especially in those areas experiencing rapid development. Such strategies must be based on a sound knowledge of the total mineral aggregate resource base at both local and regional levels. The purpose of the Aggregate Resources Inventory is to provide the basic geological information required to include potential mineral aggregate resource areas in planning strategies and official plans. The reports should form the basis for discussion on those areas best suited for possible extraction. The aim is to assist decision-makers in protecting the public well-being by ensuring that adequate resources of mineral aggregate remain available for future use.

This report is a technical background document, based for the most part on geological information and interpretation. It has been designed as a component of the total planning process and should be used in conjunction with other planning considerations, to ensure the best use of a municipality's resources.

The report includes an assessment of sand, gravel and crushed bedrock. The most recent information available has been used to prepare the reports. As new information becomes available, revisions may be necessary.

[1] Manuscript accepted for publication by Chief Engineering and Terrain Geology Section, May 10, 1983.
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PART I – INVENTORY METHODS

FIELD AND OFFICE METHODS

The methods used to prepare the report involved the interpretation of published geological data such as bedrock and surficial geology maps and reports (see References) as well as field examination of potential resource areas. Field methods included the examination of natural and man-made exposures of granular material. Most observations were made at quarries and sand and gravel pits located from records held by the Ontario Ministry of Transportation and Communications, the Ontario Geological Survey, and by Regional and District Offices of the Ontario Ministry of Natural Resources. Observations made at pit sites included estimates of the total face height and the proportion of gravel- and sand-sized fragments in the deposit. Observations were also made of the shape and lithology of the particles. These characteristics are important in estimating the quality and quantity of the aggregate. In areas of limited exposure, test pitting, soil probing and hand-augering techniques were used to assess subsurface materials. Airphotos at various scales were used to determine the continuity of deposits, especially in areas where information is limited.

Deposits with potential for further extractive development or those where existing data are scarce, were studied in greater detail. Representative layers in these deposits were sampled in 25- to 100-pound (11- to 45-kg) units either from existing pit faces or from backhoe test holes. The samples were analysed for grain size distribution and in some cases for petrographic assemblage. Analyses were performed in the laboratories of the Soils and Aggregates Section, Ontario Ministry of Transportation and Communications. In areas of limited subsurface exposure, 9- to 15-foot (3- to 5-m) sections were excavated, using a powered auger. The stratigraphic section in these test holes was described and bulk samples were taken to better assess the potential of the deposit. The symbols for and locations of sample and test hole sites are noted on Map 1.

In the office, the field data were supplemented by pit information on file with the Engineering Materials Office of the Ontario Ministry of Transportation and Communications. Data contained in these files include field estimates of the depth, composition and "workability" of deposits as well as laboratory analyses of the physical properties and chemical suitability of the aggregate. Information concerning the development history of the pits and acceptable uses of the aggregate is also recorded. The locations of additional sources were obtained from records held by Regional and District Offices of the Ontario Ministry of Natural Resources. The cooperation of the above named groups in the compilation of inventory data is gratefully acknowledged.

Water well records, held by the Ontario Ministry of the Environment, were used in some areas to corroborate thickness estimates, or to indicate the presence of buried granular material. These records were used in conjunction with other evidence. Topographic maps of the National Topographic System, at a scale of 1:50 000, were used as a compilation base for the field and office data. The information was then transferred to a township base map, also at a scale of 1:50 000, prepared by the Cartography Section of the Lands and Waters Group, Ontario Ministry of Natural Resources, for presentation in the report.

RESOURCE TONNAGE CALCULATION TECHNIQUES

SAND AND GRAVEL RESOURCES

Once the interpretative boundaries of the aggregate units have been drawn, quantitative estimates of the possible resources available can be made. Generally, the volume of a deposit can be calculated if its areal extent and average thickness are known or can be estimated. The computation methods used are as follows. First, the area of the deposit, as outlined on the final base map, is calculated in acres. The thickness values used are an approximation of the deposit thickness, based on the face heights of pits developed in the deposit or on subsurface data such as test holes and water well logs. Original tonnage values can then be calculated by multiplying the volume of the deposit by 2500 (the density factor). This factor is approximately the number of tons in a one-foot (0.3-m) thick layer of sand and gravel, one acre (0.4 ha) in extent, assuming an average density of 110 pounds per

cubic foot (1766 kg per cubic metre).

Tonnage = Area x Thickness x Density Factor

Tonnage calculated in this manner must be considered only as an estimate. Furthermore, such tonnages represent amounts that existed prior to any extraction of material (i.e. original tonnage) (Table 1, Column 4).

The Selected Sand and Gravel Resource Areas in Table 3 are calculated in the following way. Two successive subtractions are made from the total area. Column 3 accounts for the number of acres unavailable due to the presence of permanent cultural features and their associated setback requirements. Column 4 accounts for those areas that have previously been extracted. The remaining figure is the area of the deposit currently available for extraction (Column 5). The available area is then multiplied by the estimated deposit thickness and the density factor (Column 5 x Column 6 x 2500) to give an estimate of the sand and gravel tonnage presently available for extractive development and/or resource protection.

Reserve estimates are calculated for deposits of primary significance. Reserve estimates for deposits of secondary and tertiary significance are not calculated in Table 3, however the aggregate potential of these deposits is discussed in the report.

BEDROCK RESOURCES

The method used to calculate resources of bedrock-derived aggregate is much the same as that described above. The areal extent of bedrock formations overlain by less than 25 feet (8 m) of unconsolidated overburden is determined from bedrock geology maps and from the interpretation of available subsurface data. In some areas, drift thickness values were inferred from terrain units used in Engineering and Terrain Geology mapping of parts of northern Ontario. The measured extent of such areas is then multiplied by the estimated quarriable thickness of the rock unit. In most cases a standardized estimate of a quarriable thickness of 60 feet (18 m) is used. Although the thicknesses of the Precambrian bedrock units in northern Ontario are all probably considerably greater, the 60-foot (18-m) value is considered an appropriate estimate of the maximum thickness of material that can be economically and technologically extracted from a given quarry face. Volume estimates are then multiplied by 3700, which is the estimated weight, in Imperial tons, of a one-foot (0.3-m) thick section of Precambrian granitic rock one acre (0.4 ha) in extent, assuming a bulk density of 170 pounds per cubic foot (2729 kg per cubic metre).

UNITS AND DEFINITIONS

Although most of the measurements and other primary data available for resource tonnage calculations are given in Imperial units, Metric units have also been given in the text and on the tables which accompany the report. The Metric equivalent of the data is shown in brackets after or directly below the corresponding Imperial figures. Data are generally rounded off in accordance with the Ontario Metric Practice Guide (Metric Committee 1975).

The tonnage estimates made for sand and gravel as well as bedrock-derived aggregate are termed possible resources in accordance with terminology of the Ontario Resource Classification Scheme (Robertson 1975, p.7) and with the Association of Professional Engineers of Ontario (1976) (see Appendix B).

PART II - DATA PRESENTATION AND INTERPRETATION

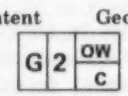
For each map area there are three maps, each portraying a different aspect of the aggregate resources in the report area. Maps 1A and 1B, "Distribution of Sand and Gravel Deposits", give a comprehensive inventory of the sand and gravel resources in the report area. Maps 2A and 2B, "Selected Sand and Gravel Resource Areas", show those deposits which are considered to represent the largest and/or highest quality resources in the area. Maps 3A and 3B, "Bedrock Resources", show the distribution of bedrock formations, the distribution of overlying unconsolidated sediments, and identifies the Selected Bedrock Resource Areas.

MAPS 1A and 1B: DISTRIBUTION OF SAND AND GRAVEL DEPOSITS

Maps 1A and 1B are derived directly from existing surficial geology maps or from airphoto interpretation in areas where mapping is incomplete. The maps represent a comprehensive inventory of all sand and gravel deposits within the study area and serve as a base for the calculation of total sand and gravel resources. All known deposits are delineated by a dashed line and given a brown or beige tone. The present level of extractive activity is also indicated. The maps represent a summary of all available information related to the quantity and quality of aggregate in the mapped deposits. Much of this information is contained in two symbols which appear on the maps. The Deposit Symbol appears for each mapped deposit and summarizes important genetic and textural data. The Texture Symbol is a circular proportional diagram which displays the grain size distribution of the aggregate in areas where bulk samples were taken.

DEPOSIT SYMBOL

The Deposit Symbol is similar to those used in soil mapping and land classification systems commonly in use in North America. The components of the symbol indicate the gravel content, thickness of material, origin (type), and quality limitations for every deposit shown on Maps 1A and 1B. These components are illustrated by the following example:



This symbol identifies an outwash deposit 10 to 20 feet (3 to 6 m) thick containing more than 35 percent gravel. Excess silt and clay may limit uses of the aggregate in the deposit.

The "gravel content" and "thickness class" are basic criteria for distinguishing different deposits. The "gravel content" symbol is an upper case "S" or "G". The "S" indicates that the deposit is generally "sandy" and that gravel-sized aggregate makes up less than 35 percent of the whole deposit. "G" indicates that the aggregate probably contains more than 35 percent gravel.

The "thickness class" indicates a depth range which is related to the potential resource tonnage for each deposit. Four thickness class divisions have been established as shown in the legend for Maps 1A and 1B.

Two smaller sets of letters, divided from each other by a horizontal line, follow the thickness class number. The upper series of letters identifies the geologic deposit type (the types are summarized with respect to their main geologic and extractive characteristics in Appendix C) and the lower series of letters identifies the main quality limitations that may be present in the deposit as discussed in the next section.

TEXTURE SYMBOL

The Texture Symbol provides a more detailed assessment of the grain size distribution in deposits where samples were taken during field study. The data from which these symbols are derived has been plotted on grain size distribution graphs. The relative amounts of gravel, sand, and silt and clay in the sampled material are shown graphically by the subdivision of a circle into proportional segments. The following example shows a hypothetical sample consisting of 30 percent gravel, 60 percent sand and 10 percent silt and clay:

Test hole locations are shown on Maps 1A and 1B by a solid drill hole symbol. All known sand and gravel pits, whether presently active or inactive, are shown by a dot symbol and a number which refers to the pit descriptions given in Table 2. Each description notes the location and owner of the pit and the estimated face height and gravel content.

MAPS 2A and 2B: SELECTED SAND AND GRAVEL RESOURCE AREAS

Maps 2A and 2B are interpretative maps derived from an evaluation of the deposits shown on Maps 1A and 1B. The deposits identified on Maps 2A and 2B are those which are considered to be important in ensuring an adequate resource base for the future.

All the selected sand and gravel resource areas are first delineated by geological boundaries and then classified into three levels of significance: primary, secondary, and tertiary. These areas are identified on Maps 2A and 2B by different shading patterns.

Each area of primary significance is assessed as to its probable relative value as a resource in the municipality and is given a deposit number. All such deposits are shown by a red tone on Maps 2A and 2B.

Selected Sand and Gravel Resource Areas of primary significance are not permanent, single land use units which must be incorporated in an official planning document. They represent areas in which a major resource is known to exist. Such Resource Areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

Deposits of secondary significance are not ranked numerically in this report, but are indicated by a light red tone on the maps. Such deposits are believed to contain significant amounts of sand and gravel. Although deposits of secondary significance are not considered to be the "best" resource areas in a municipality, they may contain large quantities of sand and gravel and should be considered as an important part of the aggregate supply of the municipality.

Areas of tertiary significance are outlined on the map by a solid line but have no tone. They are neither rated nor considered to be important resource areas because of their low available resources, or because of possible difficulties in extraction. Such areas may be useful for local needs but are unlikely to support large-scale development.

The process by which deposits are evaluated and selected involves the consideration of two sets of criteria. The main selection criteria are site specific, related to the characteristics of individual deposits. Factors such as deposit size, aggregate quality, and deposit location and setting are considered in the selection of those deposits best suited for extractive development. A second set of criteria involves the assessment of local aggregate resources in relation to the quality, quantity, and distribution of resources in the region in which the report area is located. The intent of such a process of evaluation is to ensure the continuing availability of sufficient resources to meet possible future demands.

SITE SPECIFIC CRITERIA

DEPOSIT SIZE

Ideally, selected deposits should contain available sand and gravel resources large enough to support a commercial pit operation using a stationary or portable processing plant. In practice, much smaller deposits may be of significant value depending on the overall reserves in the rest of the municipality. Generally, deposits in Class 1, i.e. those thicker than 20 feet (6 m) and containing more than 35 percent crushable gravel are considered to be most favourable for commercial development. Thinner deposits may be valuable in municipalities with low total resources.

AGGREGATE QUALITY

The limitations of natural aggregates for various uses result from variations in the lithology of the particles composing the deposit, and from variations in the size distribution of these particles.

Four indicators of the quality of aggregate may be included in the symbol for each deposit on Maps 1A and 1B. They are: gravel content (G or S), fines (C), oversize (O) and lithology (L).

Three of the indicators deal with grain size distribution. The gravel content, (G or S), indicates the suitability of aggregate for various

uses. Deposits containing at least 35 percent gravel in addition to a minimum of 20 percent material greater than the 26.5 mm seive are considered to be the most favourable extractive sites, since this content is the minimum from which crushed products can be economically produced.

Excess fines (high silt and clay content) may severely limit the potential use of an aggregate. Fines content in excess of 10 percent may impede drainage in road sub-base aggregate and render it more susceptible to the effects of frost action. In asphalt aggregate, excess fines hinder the bonding of particles. Deposits known to have a high fines content are indicated by a "C" in the quality portion of the Deposit Symbol.

Deposits containing more than 20 percent oversize material (greater than 4 inches (10 cm) in diameter) may also have use limitations. The oversize component is unacceptable for all concrete aggregate and for road-building aggregate, so it must be either crushed or removed during processing. Deposits known to have an appreciable oversize component are indicated by an "O" in the quality portion of the Deposit Symbol.

The other indicator of the quality of an aggregate is lithology. Just as the unique physical and chemical properties of bedrock formations determine their value for use as crushed rock, so do various lithologies of particles in a sand and gravel deposit determine its suitability for various uses. The presence of objectionable lithologies such as chert, siltstone, and shale, even in relatively small amounts, can result in a reduction in the quality of an aggregate, especially for high quality uses such as concrete and asphalt. Similarly, highly weathered, very porous and friable rock can restrict the quality of an aggregate. Deposits known to contain objectionable lithologies are indicated by an "L" in the quality component of the Deposit Symbol.

If the Deposit Symbol indicates either "C", "O", or "L" or any combination, the quality of the deposit is considered to be reduced for some uses of the aggregate. No attempt has been made to quantify the degree of limitation imposed. Assessment of the four indicators is made from published data, from data contained in files of the Ontario Ministry of Transportation and Communications and the Engineering and Terrain Geology Section of the Ontario Geological Survey, and from field observations.

Analyses of unprocessed samples obtained from test holes and pits have been plotted on grain size distribution graphs. These figures are divided into either coarse or fine aggregate graphs. The coarse aggregate graphs show samples with greater than 35 percent gravel, while the fine aggregate graphs show samples with less than 35 percent gravel. Also on the graphs are the gradation specification envelopes for Ontario Ministry of Transportation and Communications' products: Granular Base Course A, B, and C. By plotting the gradation curves with respect to the specification envelopes, it can be determined how well the unprocessed sampled material meets the criteria for each product.

LOCATION AND SETTING

The location and setting of a resource area has a direct influence on its value for possible extraction. The evaluation of a deposit's setting is made on the basis of natural and man-made features which may limit or prohibit extractive development.

First, the physical context of the deposit is considered. Deposits with some physical constraint on extractive development, such as thick overburden or high water table, are less valuable resource areas because of the difficulties involved in resource recovery. Second, permanent man-made features, such as roads, railways, powerlines, and housing developments, which are built on a deposit, may prohibit its extraction. The constraining effect of legally required setbacks surrounding such features is included in the evaluation. A quantitative assessment of these constraints can be made by measurement of their areal extent directly from the topographic maps. The area rendered unavailable by these features is shown for each resource area in Table 3 (Column 3).

The assessment of sand and gravel deposits and bedrock resource areas with respect to local land use and to private land ownership is an important component of the general evaluation process. These aspects of the evaluation process are not considered further in this report, but readers are encouraged to discuss them with personnel of the pertinent District Office of the

Ontario Ministry of Natural Resources.

REGIONAL CONSIDERATIONS

In selecting sufficient areas for resource development, it is important to assess both the local and the regional resource base, and to forecast future production and demand patterns.

Some appreciation of future aggregate requirements in an area may be gained by assessing its present production levels and by forecasting future production trends. Such an approach is based on the assumptions that production levels in an area closely reflect the demand and that the present production "market share" of an area will remain roughly at the same level.

The aggregate resources in the region surrounding a municipality should be assessed in order to properly evaluate specific resource areas and to adopt optimum resource management plans. For example, a municipality that has large resources in comparison to its surrounding region constitutes a regionally significant resource area. Municipalities with high resources in proximity to large demand centres, such as metropolitan areas, are special cases.

Although an appreciation of the regional context is required to develop comprehensive resource management techniques, such detailed evaluation is beyond the scope of this report. The selection of resource areas made in this study is based primarily on geological data or on considerations outlined in preceding sections.

MAPS 3A AND 3B BEDROCK RESOURCES

Maps 3A and 3B are interpretative maps derived from bedrock geology maps, water well data from the Ontario Ministry of the Environment, drilling assessment data from the Ontario Ministry of Natural Resources and from the Northern Ontario Engineering Geology Terrain Studies produced for the Ontario Geological Survey. Maps 3A and 3B are based on concepts similar to those outlined for the previous maps, but display both the inventory and evaluation on the one map.

The geological boundaries of the bedrock units are shown by a dashed line. Drift-covered bedrock is indicated by two blue tones and is delineated by drift thickness contour lines. The delineation of these areas has been inferred primarily from terrain units identified on Data Base Maps of the Northern Ontario Engineering Geology Terrain Studies, which exist for much of northern Ontario.

Areas where bedrock outcrops or is within 3 feet (1 m) of the ground surface are indicated by dark blue tone. Isolated bedrock outcrops which lie outside these areas are indicated by a black "X" symbol. These areas constitute potential resource areas of primary significance, because of their easy access. Areas where the bedrock is covered by 3 to 25 feet (1 to 8 m) of drift are indicated by medium blue tone. Quarrying is possible in this depth of overburden and these also represent potential resource areas. Outside the delineated areas of thin drift cover, the bedrock can be assumed to be overlain by more than 25 feet (8 m) of drift. These areas constitute resources which have extractive value only in specific circumstances and it is unlikely these areas will constitute resource areas of economic significance.

Scattered bedrock outcrops and areas of thin drift may occur in all the areas, but may not be shown on the maps due to the scale of the original mapping.

Other inventory information presented on Map 3 is designed to give an indication of the present level of extractive activity in the report area. All known quarries are shown by a dot symbol and identified by a number which refers to the quarry descriptions in Table 5. Each description notes the owner, location, and an estimate of face height. One additional symbol appears on the map: an open dot indicates the location of a selected well which penetrates bedrock. The overburden thickness is shown in feet beside the open dot.

SELECTION CRITERIA

Criteria equivalent to those used for sand and gravel deposits are used to select bedrock areas most favourable for extractive development.

The evaluation of bedrock resources is made primarily on the basis of performance and suitability data established by laboratory testing at the Ontario Ministry of Transportation and Communications. The main characteristics of the bedrock units found in the study area are summarized in Appendix D.

Deposit "size" is related directly to the areal extent of thin drift cover overlying favourable bedrock formations. Quality of the aggregate derived from specific bedrock units is established by the performance standards previously mentioned. Location and setting criteria and regional considerations are identical to those for sand and gravel deposits.

SELECTED RESOURCE AREAS

Selection of bedrock resource areas has been restricted to a single level of significance. Two factors support this approach: (1) the areal extent of a given quarry operation is much smaller than that of a sand and gravel pit producing an equivalent tonnage of material and (2) crushed bedrock has a higher unit value than sand and gravel, therefore longer haul distances can be considered. These factors allow the identification of alternative sites having similar development potential. The wide range of possible resource areas allows greater flexibility in locating quarry operations away from areas of intense land use competition. The selected areas are shown on Maps 3A and 3B by a line pattern and the calculated available tonnages are given in Table 6.

It should be stressed that the Precambrian Shield rocks in northern Ontario are generally more complex and variable than the Paleozoic rocks of southern Ontario. They often show wide variations in mineralogy, texture (grain size) and degree of weathering, even within specific rock types and over relatively short distances. As these factors are considered important in determining the suitability of the bedrock for use as aggregate, the aggregate potential may also vary considerably from location to location.

Careful selection is especially important if the bedrock is to be used as concrete aggregate. Deleterious chemical reactions may develop in the concrete which can lead to its eventual deterioration. Fortunately, these chemical reactions should not influence the use of bedrock-derived aggregate for hot-laid asphaltic and road base material. However, highly weathered, very porous and friable rock should be avoided for all uses.

For these reasons, the total area selected as a bedrock resource should not be considered acceptable for aggregate use. They are, however, areas in which the probability of finding a supply of acceptable aggregate is considered most likely.

Selected Bedrock Resource Areas are not permanent, single land use units which must be incorporated in an official planning document. They represent areas in which a major bedrock resource is known to exist. Such Resource Areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

PART III - ASSESSMENT OF AGGREGATE RESOURCES IN THE SMOOTH ROCK FALLS AREA

LOCATION AND POPULATION

The Smooth Rock Falls Area occupies an area of 362,880 acres (146 858 ha) in the south-central part of the District of Cochrane. The project area consists of Alexandra, Colquhoun, Haggart, Kendrey, Shackleton, Sydere and Webster Townships and is situated midway between Kapuskasing and Cochrane along King's Highway 11. The area is shown on portions of the Wakusimi River (42 G/1), Kapuskasing (42 G/8), Cochrane (42 H/3), Bradburn Lake (42 H/4), Smooth Rock Falls (42 H/5) and Gardiner (42 H/6) map sheets of the National Topographic System at a scale of 1:50 000.

The total population of the Smooth Rock Falls Area was 3430 in 1980. The Town of Smooth Rock Falls (Population 2328) in Kendrey Township is the largest population centre in the area (Cochrane Regional Assessment Office, City of Timmins, personal communication, 1981). Other population centres include the community of Fauquier (Population 546) in Shackleton Township, as well as the smaller settlements of Gregoires Mill, Strickland, and Departure Lake. All population centres in the project area are located along King's Highway 11. The populations of the townships are as follows: Kendrey 2371; Shackleton 831; Haggart 222; Colquhoun 6; while Alexandra, Sydere and Webster have no permanent residents (Cochrane Regional Assessment Office, City of Timmins, personal communication, 1981).

Major industries in the area include the Abitibi-Price Inc. pulp and paper mill and Trans Canada Pipelines, both of which operate in the Town of Smooth Rock Falls. The Town of Smooth Rock Falls had a population of 2302 in 1982, representing a slight decrease since 1976 (Ontario Ministry of Municipal Affairs and Housing 1983; Ontario Ministry of Treasury, Economics and Intergovernmental Affairs 1977). However, recent housing developments in the town and an increasing number of recreational residences are indicative of renewed growth in the area. This growth may increase the demand for sand and gravel for road building and construction.

Much of the project area remains inaccessible. The existing transportation network consists of King's Highway 11, Secondary Highway 634, and several township and logging roads. A line of the Canadian National Railways runs parallel to the highway.

PHYSIOGRAPHY AND SURFICIAL GEOLOGY

The physiography and distribution of unconsolidated sediments, including sand and gravel deposits, are the result of glacial activity which took place during the Wisconsinan Substage of the Pleistocene Epoch. The Wisconsinan lasted from approximately 100 000 to 7000 years ago, and was marked by the repeated advance and melting back of massive, continental ice sheets.

The ice advanced southward depositing large amounts of stony, silty sand to sand till. It is referred to as the lower or Matheson till (Hughes 1959), which is correlative to the Adams Till of the Moose River basin (Skinner 1973), and underlies much of the Northern Clay Belt. This till is, in places, suitable for use as fill.

The deglaciation of the Smooth Rock Falls area began about 9500 years ago (Prest 1970). In many places meltwaters flowing in tunnels or in crevasses in the ice deposited masses of sand and gravel along their course. These deposits formed long sinuous ridges known as eskers. During the melting back of the ice mass, the project area was inundated by Lake Barlow-Ojibway. The esker streams discharged into this glacial lake, depositing some of their sediment load around the esker, forming deltas. Combined, these two landforms are referred to as esker complexes.

Two esker complexes trend north-south through the project area. One traverses eastern Colquhoun Township and is, in part, situated within Greenwater Provincial Park. The other esker complex trends across Alexandra, Haggart and Sydere Townships. For the most part, they consist of sand, although gravel lenses may occur in the esker ridges. The two esker systems are the major potential sources of high-specification aggregate for road building and construction.

At the ice margin, meltwater exiting into the lake deposited ice-contact stratified drift in Kendrey and Sydere Townships. These deposits are predominantly sand containing small amounts of poorly sorted gravel.

The waters of Lake Barlow-Ojibway reworked some of the lower till and the glaciofluvial sediments producing glaciolacustrine deposits. A glaciolacustrine plain deposit is delineated in Shackleton Township. Composed of silt and very fine to medium sand, it is of limited value as aggregate because of the high fines content.

A minor readvance of the ice sheet (Boissonneau 1966) deposited a fine-grained, silty clay till of variable depth over all the pre-existing deposits. This till has been referred to as the Cochrane till by Hughes (1959; 1965). The high fines content of this till makes it unacceptable for construction purposes and it must be stripped off before extraction of aggregate in underlying sediments can proceed. This clay till characterizes the landscape of the Northern Clay Belt in the Smooth Rock Falls area.

The deposition of alluvium and the development of numerous swamps have also modified the physiography of the project area. Alluvium occurs along the course of existing creeks and rivers. Abundant swamps exist in low lying areas underlain by Cochrane till.

EXTRACTIVE ACTIVITY

Twenty-five sand and gravel pits and two quarries have been developed in the Smooth Rock Falls Area. In 1981, six pits were found to be active or recently used. Five of these pits are located in the esker complex in Haggart Township while the sixth is located in the ice-contact deposit in the southeast corner of Sydere Township. The remaining pits and both quarries are active on demand, inactive, abandoned, overgrown and/or depleted having not been used for some time. Two pits are currently extracting aggregate which is suitable for a range of high-specification products for road building and construction.

SELECTED SAND AND GRAVEL RESOURCE AREAS

The sand and gravel deposits selected for possible resource protection in the Smooth Rock Falls project area are shown on Maps 2A and 2B. Several esker deposits located in Alexandra, Colquhoun, Haggart and Sydere Townships have been selected as Sand and Gravel Resource Areas of Primary Significance. These deposits occupy an available area of 1300 acres (530 ha). They contain possible sand and gravel resources of approximately 89 million tons (81 million tonnes). The parts of the selected resource areas available for extraction represent 5 percent of the total area occupied by sand and gravel deposits in the project area and 13 percent of the total resource tonnage. The selected areas contain much of the report area's possible resources of crushable gravel. However, sand is the dominant sediment in most of the resource areas. Gravel lenses are present in some pits and further investigation may reveal greater amounts of gravel, especially in the esker ridges. Silt and clay are present in varying amounts in all selected areas and limit the quality of the extracted material.

An ice-contact stratified drift deposit and a number of deltaic deposits situated within the project area, have been selected as Sand and Gravel Resource Areas of Secondary Significance. Although these deposits are not the "best" resource areas, they should be considered as an important component of the project area's aggregate supply. These deposits may provide alternate sites for extractive development, especially for local use.

In two areas, the identified sand and gravel resources are unavailable for extraction. The resources within the cultural constraint boundary surrounding Departure Lake have not been selected because of existing planning constraints (G. A. Wright, District Manager, Ontario Ministry of Natural Resources, Cochrane, personal communication, 1982). The deposits within Greenwater Provincial Park have also not been selected.

SELECTED SAND AND GRAVEL RESOURCE AREAS 1 AND 2: HAGGART TOWNSHIP

Selected Sand and Gravel Resource Areas 1 and 2 consist of two esker segments in Haggart Township (Map 2B). These deposits extend south from King's Highway 11 to Departure Lake. The relief of Resource Areas 1 and 2 is low, ranging from 5 to 15 feet (1.5 to 5 m). Two gravel pits are located in these deposits (pit nos. 16 and 19).

Pit no. 19 is located in Resource Area 1. Face heights range from 40 to 50 feet (12 to 15 m) exposing two distinct types of variably bedded sediments; silty very fine sand to medium sand and fine to coarse sand with thin layers of gravel with clay coatings on the gravel particles. A fine to coarse sand layer was sampled revealing 8 percent gravel and 91 percent sand (Figure 3c, pit 19b). Poorly sorted fine to coarse gravel is present beneath the pit floor. This gravel is situated below the water table and a sample contained 53 percent gravel and 46 percent sand (Figure 3c, pit 19a). Material from this pit has been used for Granular Base Course (G.B.C.) C and winter sand.

Pit no. 16 has been developed in Resource Area 2. Faces are 30 feet (9 m) high revealing fine to medium sand with only trace amounts of gravel. This pit has supplied G.B.C. C and Hot-Laid (H.L.) No. 4 asphaltic sand for local requirements. In some sections, however, the sediment grades fine for these uses and blending is required. The veneer of Cochrane till overlying this deposit is of variable thickness. Ten feet (3 m) of the till was revealed at test hole HG-TH-2.

Selected Resource Area 1 comprises 29 acres (12 ha). Previous extraction reduces the available area of the Resource Area to 24 acres (10 ha). Assuming an average thickness of 35 feet (11 m), available sand and gravel resources are estimated to be 2 million tons (2 million tonnes).

Selected Resource Area 2 occupies 80 acres (32 ha). Cultural constraints reduce the available area of the Resource Area to 60 acres (24 ha). Assuming an average thickness of 30 feet (9 m), available sand and gravel resources are estimated to total 4 million tons (4 million tonnes).

Both Resource Areas are well situated in the central part of the project area, with respect to road access and local demand centres.

SELECTED SAND AND GRAVEL RESOURCE AREA 3: ALEXANDRA AND HAGGART TOWNSHIPS

Selected Sand and Gravel Resource Area 3 consists of two esker segments that trend north-south across central Alexandra Township into northern Haggart Township. The northernmost segment has been labelled 3a and the southernmost 3b on Map 2B. Both areas consist of a discontinuous, low lying ridge ranging from 5 to 25 feet (1.5 to 8 m) in height. Airphoto interpretation has been used to delineate the boundaries of the deposits. Selection is based on evidence from pit no. 13 and from pits in the esker deposits to the south in Haggart Township. Only the southern part of Resource Area 3b in Haggart Township has been developed for extraction.

Pit no. 13 located on the edge of Area 3b has 30- to 45-foot (9- to 14-m) faces exposing very fine to coarse sand with occasional gravel lenses. A sample of the very fine to coarse sand contained 7 percent gravel and 90 percent sand (Figure 3a, pit 13b). A gravel lens was also sampled and yielded 52 percent gravel and 47 percent sand (Figure 3a, pit 13a). Two test holes were placed in the pit floor. Test hole HG-TH-12 revealed 20 feet (6 m) of medium to coarse sand with minor amounts of gravel. Gravel may be present at a depth of 20 feet (6 m) (Table 7). A sample from test hole HG-TH-6 contained 11 percent gravel and 86 percent sand (Figure 3a). The aggregate from this pit is suitable for G.B.C. A, B, and C, although sand control is required for G.B.C. A. The sand fraction of the aggregate requires blending for use as H.L. 4 sand. Some of the gravel lenses contain crushable material.

Material similar to that exposed in pit no. 13 may also be present in the undeveloped parts of the Resource Area, although, additional subsurface testing is required.

The two segments of Resource Area 3 total 700 acres (285 ha). Cultural constraints reduce the available area to 495 acres (200 ha). Assuming an average thickness of 30 feet (9 m), the available sand and gravel resources are estimated to total 37 million tons (34 million tonnes).

SELECTED SAND AND GRAVEL RESOURCE AREA 4: COLQUHOUN TOWNSHIP

Selected Sand and Gravel Resource Area 4 consists of three esker segments that form part of the esker complex situated in Colquhoun Township, north of Greenwater Provincial Park. The segments, labelled Area 4a, 4b and 4c on Map 2A, range in relief from 20 to 45 feet (6 to 14 m). Each segment is flanked by kettle depressions and deltaic sediments. No pits currently exist in these deposits. Selection of the

Resource Area was based on airphoto interpretation and the quality of material extracted from pits in the same esker complex to the south in Clute Township (situated southeast of Colquhoun Township, outside the project area). Subsurface testing is required to establish the quality of the aggregate in these deposits.

The esker segments making up Resource Area 4 occupy a total area of 215 acres (87 ha). Cultural setbacks reduce the area currently available for extraction to 95 acres (38 ha). Assuming an average deposit thickness of 25 feet (8 m), available sand and gravel resources are estimated to be 6 million tons (5 million tonnes). Access to the Area is provided by Wolf Lake Road.

SELECTED SAND AND GRAVEL RESOURCE AREA 5: HAGGART AND SYDERE TOWNSHIPS

Selected Sand and Gravel Resource Area 5 is a series of bead-like segments of the same esker that forms Resource Areas 1, 2 and 3. The esker segments, labelled 5a to 5h on Map 2B, extend from the southern end of Departure Lake in Haggart Township to southern Sydere Township. The boundaries of the Resource Area have been delineated by airphoto analysis. This Area may contain similar material to that exposed in the Resource Areas situated to the north, however, detailed subsurface testing is required.

Selected Resource Area 5 totals 660 acres (265 ha). Cultural setbacks reduce the area currently available for extraction to 620 acres (250 ha). Assuming an average deposit thickness of 25 feet (8 m), sand and gravel resources are approximately 40 million tons (36 million tonnes). At present there is no road access to any part of this Resource Area.

SAND AND GRAVEL RESOURCE AREAS OF SECONDARY SIGNIFICANCE

The glaciolacustrine delta deposits flanking the esker ridges that form Selected Resource Areas 1, 2, 3 and 5 in Alexandra, Haggart and Sydere Townships have been selected as Sand and Gravel Resource Areas of Secondary Significance. Five pits have been opened in one of these deposits in Haggart Township. Face heights range from 20 to 60 feet (6 to 18 m) exposing sand with minor amounts of gravel. Silt seams are also present in some of the pits. The aggregate from these pits is generally suitable for G.B.C. C and fill, although in places blending is required to produce G.B.C. C. Blending is also required for hot-laid asphaltic sand. A sample from a gravel pocket from beneath the floor of pit no. 17 contained 20 percent gravel and 78 percent sand (Figure 3b). Test hole HG-TH-14 uncovered 40 feet (12 m) of fine to coarse sand with minor amounts of gravel, silt, and clay.

It should be stressed that parts of these secondary resource areas are overlain by over 10 feet (3 m) of clayey Cochrane till which may prohibit extractive development. Test hole AL-TH-7 revealed over 10 feet (3 m) of clay till while test hole HG-TH-13 uncovered 15 feet (5 m) of clay till over 25 feet (8 m) of varved silt and clay, making extraction of aggregate prohibitive at this site. Both the clay till and varved silt and clay must be removed if extraction of the underlying aggregate is to proceed.

An ice-contact stratified drift deposit located in southeastern Sydere Township has also been selected as a Sand and Gravel Resource Area of Secondary Significance. This deposit should be considered for possible resource protection because it represents an accessible deposit suitable for supplying the local needs for logging roads and fill in the southern part of the project area. A sample taken from a gravel area in pit no. 25 contained 27 percent gravel and 72 percent sand (Figure 4a). A second sample taken from a test hole in the pit floor yielded 1 percent gravel and 97 percent sand (Figure 4a, SY-TH-10). The boundaries of this deposit have been delineated by airphoto interpretation.

A glaciolacustrine delta deposit is located in the southwestern corner of Colquhoun Township. There are four abandoned sand pits in the deposit. A sample from pit no. 6 contained 91 percent sand and 9 percent fines (Figure 2). The aggregate from these pits may be suitable for fill. Glaciolacustrine plain sediments overlie the deltaic material in parts of this deposit. Nine feet (3 m) of these sediments were noted at test hole CO-TH-11.

The final area selected for resource protection at the secondary level is the glaciolacustrine delta deposit flanking Resource Area 4 in Colquhoun Township. Little subsurface information is available for this deposit, however, based on information for the other delta deposits in the project area, significant quantities of sand may be present.

BEDROCK GEOLOGY

The Smooth Rock Falls Area is underlain by bedrock of the Superior Province of the Canadian Shield. The bedrock is composed predominantly of migmatite-metasedimentary-metavolcanic complex rocks and felsic intrusive rocks of Early Precambrian age. Diabase dikes of Early to Late Precambrian age are also present in the study area (Bennett et al. 1967a).

The bedrock is covered by an irregular veneer of glacial drift with a few randomly distributed bedrock exposures. Generally, areas of higher relief have thinner drift cover than lower lying areas. Drift thickness contour lines, shown on Maps 3A and 3B, are derived from water well data, air photo interpretation and interpretation of published terrain mapping of the project area (Lee 1979).

Migmatite-metasedimentary-metavolcanic complex rocks (Rock Type A) have a varied composition and metamorphic structure (Bennett et al. 1967a). Pre-existing sedimentary rocks were subjected to high temperatures and pressures during metamorphism causing deformation and recrystallization. The process formed biotite-quartz-feldspar, hornblende-quartz-feldspar and granitic gneisses. In certain areas, lit-par-lit injections of granitic material into the gneiss complex are common. These injections have been grouped as part of the gneiss complex by Bennett et al. (1967a). Two quarries have been developed in Type A bedrock in the Smooth Rock Falls Area. The quarries produced crushed stone suitable for Granular Base Course A, but the aggregate was found to be too brittle for use in hot-laid asphalt. Areas of thinly drift-covered Type A bedrock have been selected for possible resource protection. However, the quality of this rock type may vary over relatively short distances and any site proposed for quarry development should be tested in detail before extractive development occurs.

The felsic intrusive rocks (Rock Type B) occur as batholithic intrusions and satellite stocks within the gneiss complex (Bennett et al. 1967a). The intrusive rocks vary in composition from granite to quartz monzonite to granodiorite. They range in texture from fine-grained to pegmatitic and both massive and foliated varieties occur. Some of these rocks with a high feldspar and quartz content have "stripping" problems, in that the smooth cleavage and fracture surfaces of the minerals hinder the adhesion of asphalt and concrete mixes. This problem can be circumvented by weathering the rocks for a considerable period of time in stockpiles or by adding chemicals which erode the smooth surfaces and allow better adhesion. Varieties of these rocks may also be brittle and should be avoided. No quarries in Type B bedrock exist within the project area, but similar rock has been used for crushed stone products elsewhere in northern Ontario. This rock type has also been selected for possible resource protection.

Diabase dikes (Rock Type C) cut the aforementioned rock types in the project area. The diabase is usually fine- to coarse-grained, gabbroic- to diabasic-textured rock (Bennett et al. 1967a). Both olivine- and quartz-bearing varieties occur. For the most part, the quartz-bearing diabase is hard and crushes uniformly. The olivine-bearing diabase weathers too easily for use as construction aggregate. An estimated width of at least 50 feet (15 m) is required for economical extraction of the diabase unless the surrounding rocks are also suitable for extraction (Z. Katona, Senior Aggregate Resource Engineer, M.T.C., Toronto, personal communication, 1981). Only those diabase dikes which traverse Selected Bedrock Resource Areas of Type A and B bedrock have been selected for possible resource protection.

SELECTED BEDROCK RESOURCE AREAS

An inventory of the bedrock resources in the Smooth Rock Falls Area indicates a total extent of approximately 84,000 acres (34 000 ha) overlain by less than 25 feet (8 m) of drift. The original tonnage is estimated to be 18,800 million tons (17 100 million tonnes) (Table 4). From this total, eight areas consisting of Type A, B and C bedrock have been selected for possible resource protection. They occupy a total available area of 8800 acres (3550 ha), containing possible resources of 1960 million tons (1780 million tonnes).

SELECTED BEDROCK RESOURCE AREA 1: HAGGART AND SYDERE TOWNSHIPS

Selected Bedrock Resource Area 1 is situated along the boundary of Haggart and Sydere Townships. The bedrock consists of Types A and B rock with the exception of three diabase

dikes which traverse the Area. Less than 3 feet (1 m) of drift overlies the bedrock and the topography is rolling. Several isolated bedrock outcrops exist in the Area. Access is via the Abitibi Road.

Selected Resource Area 1 occupies 4350 acres (1760 ha), of which 4250 acres (1720 ha) are currently available for extraction. Based on a workable thickness of 60 feet (18 m), presently available bedrock resources are approximately 940 million tons (850 million tonnes).

SELECTED BEDROCK RESOURCE AREA 2: COLQUHOUN TOWNSHIP

Selected Resource Area 2 is a knob of Type A rock located near the western boundary of Colquhoun Township. The bedrock is overlain by less than 3 feet (1 m) of drift. The Area is tree covered and accessible via a logging road.

Resource Area 2 occupies 450 acres (182 ha) which are presently available for extraction. Assuming a workable thickness of 60 feet (18 m), possible crushed stone resources are estimated to be 100 million tons (91 million tonnes).

SELECTED BEDROCK RESOURCE AREA 3: HAGGART AND SHACKLETON TOWNSHIPS

Selected Bedrock Resource Area 3 is located in northern Shackleton and Haggart Townships along King's Highway 11. The settlement of Strickland is situated in the western part of the Resource Area. The bedrock consists of Types A and B rock with the exception of two diabase dikes which traverse the area. The Area is overlain by approximately 15 feet (5 m) of overburden. Access is provided by King's Highway 11 as well as a line of the Canadian National Railways.

Resource Area 3 occupies a total of 1420 acres (580 ha), of which 900 acres (365 ha) are presently available for extraction. Assuming a quarriable thickness of 60 feet (18 m), the possible crushed stone resources are estimated to be 199 million tons (180 million tonnes).

SELECTED BEDROCK RESOURCE AREA 4: SHACKLETON TOWNSHIP

Selected Bedrock Resource Area 4 consists of three areas, labelled 4a, 4b and 4c on Map 3B, situated east of the community of Fauquier along King's Highway 11. The bedrock in all areas consists of Type A rock with the exception of a diabase dike which cuts across Area 4c. The Areas are overlain by 0 to 25 feet (0 to 8 m) of overburden. Two quarries have been developed in Area 4a. In both quarries, granitic gneiss was crushed for use as G.B.C. A, B, and C as well as 5/8 inch (16 mm) crushed stone. The brittle nature of these rocks makes them unacceptable for use as hot-laid asphalt. All the areas are accessible by King's Highway 11 and a line of the Canadian National Railways.

The total area occupied by Resource Areas 4a, 4b and 4c is 960 acres (390 ha), of which 800 acres (325 ha) are presently available for extraction. Assuming a workable thickness of 60 feet (18 m), currently available crushed stone resources are estimated to be 177 million tons (160 million tonnes).

SELECTED BEDROCK RESOURCE AREA 5: SHACKLETON TOWNSHIP

Selected Bedrock Resource Area 5 is located approximately 2.5 miles (4.0 km) south of the community of Fauquier in Shackleton Township. The bedrock in the Area consists of Types A and B rock overlain by less than 3 feet (1 m) of drift. Access is provided by Shackleton Road.

Resource Area 5 occupies 445 acres (180 ha), of which 435 acres (176 ha) are currently available for extraction. Based on a workable thickness of 60 feet (18 m), possible crushed stone resources are estimated to be 96 million tons (87 million tonnes).

SELECTED BEDROCK RESOURCE AREA 6: COLQUHOUN TOWNSHIP

Selected Bedrock Resource Area 6 is a knob of Type B rock located in southern Colquhoun Township. Previous investigation revealed it to be composed of massive granitic rock (Bennett et al. 1966). The Area is tree covered and the hill formed by the knob forms the highest topographic point in the project area. Access is provided by a road to the fire lookout tower on the hill.

Resource Area 6 occupies 135 acres (55 ha), of which 130 acres (53 ha) are currently available for extraction. Based on a quarriable

thickness of 60 feet (18 m), crushed stone resources are estimated to be 29 million tons (26 million tonnes).

SELECTED BEDROCK RESOURCE AREA 7: SHACKLETON TOWNSHIP

Selected Bedrock Resource Area 7 consists of two areas, labelled 7a and 7b on Map 3B, which lie in the northwestern corner of Shackleton Township. The bedrock consists of Type B rock overlain by less than 3 feet (1 m) of drift. Area 7a is accessible by King's Highway 11 and a line of the Canadian National Railways. A township road provides access to Area 7b.

The total area occupied by Resource Areas 7a and 7b is 320 acres (130 ha), of which 270 acres (109 ha) are currently available for extraction. Based on a workable thickness of 60 feet (18 m), presently available bedrock resources are estimated to be 60 million tons (54 million tonnes).

SELECTED BEDROCK RESOURCE AREA 8: ALEXANDRA TOWNSHIP

Selected Bedrock Resource Area 8 is located north of Moonbeam Lake in Alexandra Township. The Type A rock making up the Area, is covered by less than 25 feet (8 m) of overburden. Logging roads provide access to the Area.

Resource Area 8 occupies 1970 acres (800 ha), of which 1600 acres (650 ha) are currently available for extraction. Assuming a quarriable thickness of 60 feet (18 m), possible crushed stone resources are approximately 355 million tons (320 million tonnes).

SUMMARY

The Smooth Rock Falls Area, including Alexandra, Colquhoun, Haggart, Kendrey, Shackleton, Sydere and Webster Townships, is generally low in commercial sand and gravel resources, particularly crushable gravel. Five areas of primary significance and several areas of secondary significance have been selected for possible resource protection in the project area. As the area grows, pressure to produce aggregate locally should increase and care should be taken to ensure the continued availability of as much of these resource areas as possible.

As the sand and gravel deposits in the resource areas become exhausted, bedrock resources should increase in importance. Care should be taken to protect as much of the selected bedrock resources from sterilization by development as possible.

Enquiries regarding the Aggregate Resources Inventory of the Smooth Rock Falls Area should be directed to the Ontario Ministry of Natural Resources, either at the Cochrane District Office, 2 Third Avenue, Box 730, Cochrane, Ontario, P0L 1C0 (Tel. (705) 272-4365), at the Kapuskasing District Office, 6 Government Road, Kapuskasing, Ontario, P5N 2W4 (Tel. (705) 335-6191), or at the Northern Region Office, 60 Wilson Avenue, Timmins, Ontario, P4N 2S7 (Tel. (705) 267-1401).

TABLE 1 | TOTAL SAND AND GRAVEL RESOURCES, SMOOTH ROCK FALLS AREA*

1 CLASS NO.	2 DEPOSIT TYPE (see Appendix C)	3 AREAL EXTENT Acres (Hectares)	4 ORIGINAL TONNAGE Millions of Tons (Tonnes)
ALEXANDRA TOWNSHIP			
1	S-E	540 (218)	41 (37)
2	S-LD	3150 (1280)	79 (72)
3	S-LD	1510 (610)	19 (17)
		5200 (2100)	139 (126)
COLQUHOUN TOWNSHIP			
1	S-E	215 (87)	13 (12)
2	S-LD	3100 (1260)	98 (89)
3	S-LD	610 (247)	8 (7)
		3900 (1580)	119 (108)
HAGGART TOWNSHIP			
1	G-E	29 (12)	3 (3)
1	S-E	365 (148)	27 (24)
2	S-LD	3250 (1320)	82 (74)
3	S-LD	4450 (1800)	56 (51)
		8100 (3300)	168 (152)

TABLE 1 | TOTAL SAND AND GRAVEL RESOURCES, SMOOTH ROCK FALLS AREA*

1 CLASS NO.	2 DEPOSIT TYPE (see Appendix C)	3 AREAL EXTENT Acres (Hectares)	4 ORIGINAL TONNAGE Millions of Tons (Tonnes)
KENDREY TOWNSHIP			
2	S-IC	560 (227)	14 (13)
2	S-LD	32 (13)	1 (1)
		590 (239)	15 (14)
SHACKLETON TOWNSHIP			
2	S-LP	970 (390)	36 (33)
SYDERE TOWNSHIP			
1	S-E	540 (218)	34 (30)
2	S-LD	4300 (1740)	108 (98)
2	S-IC	3350 (1360)	84 (76)
		8200 (3300)	226 (205)
WEBSTER TOWNSHIP			
		– NONE –	
		27,000 (10 900)	700 (635)

* Identified deposit areas within Kettle Lakes Provincial Park and the cultural constraint boundary around Departure Lake are omitted on all tables.

N.B. Minor variations in all tables are caused by rounding of data.

TABLE 2 | SAND AND GRAVEL PITS, SMOOTH ROCK FALLS AREA

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 FACE HEIGHT Feet (Metres)	7 % GRAVEL	8 PIT STATUS
WEBSTER TOWNSHIP							
1	–	Unknown	–	–	10 (3)	5	partially overgrown
2	GA-19-1	Unknown	–	–	8 (2)	15	partially overgrown
KENDREY TOWNSHIP							
3	–	Unknown	2, 3	6	4 (1)	1	inactive
4	–	Municipal Dump	2, 3	6	10 (3)	1	inactive
COLQUHOUN TOWNSHIP							
5	–	Unknown	27	3	30 (9)	1	partially overgrown
6	–	Unknown	28	3	5 (2)	1	inactive
7	CO-24-35	Unknown	27	2	20 (6)	5	partially overgrown
8	–	Unknown	20	1	–	–	depleted
9	–	Unknown	24	1	4 (1)	5	depleted
SHACKLETON TOWNSHIP							
10	KA-11-42	Unknown	26, 27	12	10 (3)	10	partially overgrown
11	KA-11-33	Unknown	22	8	6 (2)	10	partially overgrown
12	SRF-21-13	Levesque	10	11	10 (3)	1	inactive

TABLE 2 | SAND AND GRAVEL PITS, SMOOTH ROCK FALLS AREA

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 FACE HEIGHT Feet (Metres)	7 % GRAVEL	8 PIT STATUS
HAGGART TOWNSHIP							
13	SRF-21-12	Cloutier Brothers Ltd.	19	12	30-45 (9-14)	25	active
14	SRF-21-8	Marchand & Moore	18	10	20 (6)	10	active on demand
15	SRF-21-4	Oullette & Marchand	18	9, 10	50 (15)	1	recently used
16	SRF-21-10	Moore	18	9	30 (9)	1	active on demand
17	SRF-21-1	Abitibi	16	8	60 (18)	15	recently used
18	SRF-21-3	D.H.O.	19	8	40 (12)	5	active on demand
19	SRF-21-11	Lavoie	19	8	40-50 (12-15)	35	recently used
20	BL-31-5	Labelle	19	5	40 (12)	70	recently used
21	BL-31-3	Moore and Quinn	20	5	15 (5)	15	partially overgrown
22	BL-31-1	Moore	20	5	40 (12)	45	depleted
23	BL-31-2	Unknown	20, 21	4	20 (6)	10	inactive
24	–	Unknown	4, 5	9	5 (2)	5	partially overgrown
SYDERE TOWNSHIP							
25	–	Abitibi	–	–	8 (2)	25	active

TABLE 3 | SELECTED SAND AND GRAVEL RESOURCE AREAS, SMOOTH ROCK FALLS AREA

1 DEPOSIT NO.	2 AREA Acres (Hectares)	3 CULTURAL SETBACKS Acres (Hectares)	4 EXTRACTED AREA Acres (Hectares)	5 AVAILABLE AREA Acres (Hectares)	6 ESTIMATED DEPOSIT THICKNESS Feet (Metres)	7 AVAILABLE AGGREGATE Millions of Tons (Tonnes)
KENDREY TOWNSHIP						
			– NONE –			
SHACKLETON TOWNSHIP						
			– NONE –			
WEBSTER TOWNSHIP						
			– NONE –			
HAGGART TOWNSHIP						
1	29 (12)	–	5 (2)	24 (10)	35 (11)	2 (2)
2	80 (32)	20 (8)	–	60 (24)	30 (9)	4 (4)
3b	160 (65)	–	–	160 (65)	30 (9)	12 (11)
	270 (109)	20 (8)	5 (2)	244 (99)		18 (16)
ALEXANDRA TOWNSHIP						
3a	225 (91)	110 (44)	–	115 (46)	30 (9)	9 (8)
3b	320 (130)	100 (40)	–	220 (89)	30 (9)	16 (14)
	540 (218)	210 (85)		325 (136)		25 (23)
COLQUHOUN TOWNSHIP						
4a	105 (42)	55 (22)	–	50 (20)	25 (8)	3 (3)
4b	65 (26)	50 (20)	–	15 (6)	25 (8)	1 (1)

TABLE 3 | SELECTED SAND AND GRAVEL RESOURCE AREAS, SMOOTH ROCK FALLS AREA

1 DEPOSIT NO.	2 AREA Acres (Hectares)	3 CULTURAL SETBACKS Acres (Hectares)	4 EXTRACTED AREA Acres (Hectares)	5 AVAILABLE AREA Acres (Hectares)	6 ESTIMATED DEPOSIT THICKNESS Feet (Metres)	7 AVAILABLE AGGREGATE Millions of Tons (Tonnes)
4c	45 (18)	15 (6)	–	30 (12)	25 (8)	2 (2)
	215 (87)	120 (48)		95 (38)		6 (5)
HAGGART TOWNSHIP						
5a	48 (19)	2 (1)	–	46 (19)	25 (8)	3 (3)
5b	75 (30)	–	–	75 (30)	25 (8)	5 (4)
	123 (50)	2 (1)		121 (49)		8 (7)
SYDERE TOWNSHIP						
5c	75 (30)	15 (6)	–	60 (24)	25 (8)	4 (3)
5d	130 (53)	–	–	130 (53)	25 (8)	8 (7)
5e	130 (53)	15 (6)	–	115 (46)	25 (8)	7 (6)
5f	28 (11)	–	–	28 (11)	25 (8)	2 (1)
5g	88 (36)	5 (2)	–	83 (34)	25 (8)	5 (4)
5h	92 (37)	2 (1)	–	90 (36)	25 (8)	6 (5)
	540 (218)	37 (15)		500 (202)		32 (29)
	1680 (680)	390 (158)	5 (2)	1300 (530)		89 (81)

TABLE 4 TOTAL IDENTIFIED BEDROCK RESOURCES, SMOOTH ROCK FALLS AREA*

1 DRIFT THICKNESS Feet (Metres)	2 BEDROCK LITHOLOGY	3 QUARRIABLE THICKNESS Feet (Metres)	4 AREAL EXTENT Acres (Hectares)	5 ORIGINAL TONNAGE Millions of Tons (Tonnes)
ALEXANDRA TOWNSHIP				
3-25 (1-8)	Type A	60 (18)	1970 (800)	435 (395)
COLQUHOUN TOWNSHIP				
0-3 (0-1)	Type A	60 (18)	980 (395)	218 (198)
3-25 (1-8)	Type A	60 (18)	2500 (1010)	560 (510)
			3500 (1420)	780 (710)
0-3 (0-1)	Type B	60 (18)	135 (55)	30 (27)
3-25 (1-8)	Type B	60 (18)	450 (182)	100 (91)
			580 (235)	130 (118)
			4100 (1660)	910 (830)
HAGGART TOWNSHIP				
0-3 (0-1)	Type A	60 (18)	350 (142)	78 (71)
3-25 (1-8)	Type A	60 (18)	7800 (3150)	1730 (1570)
			8200 (3300)	1810 (1640)
0-3 (0-1)	Type B	60 (18)	240 (97)	53 (48)
3-25 (1-8)	Type B	60 (18)	11,300 (4550)	2500 (2270)
			11,500 (4650)	2550 (2310)
			19,700 (8000)	4350 (3950)

TABLE 4 | TOTAL IDENTIFIED BEDROCK RESOURCES, SMOOTH ROCK FALLS AREA*

1 DRIFT THICKNESS Feet (Metres)	2 BEDROCK LITHOLOGY	3 QUARRIABLE THICKNESS Feet (Metres)	4 AREAL EXTENT Acres (Hectares)	5 ORIGINAL TONNAGE Millions of Tons (Tonnes)
KENDREY TOWNSHIP				
0-3 (0-1)	Type A	60 (18)	420 (170)	93 (84)
3-25 (1-8)	Type A	60 (18)	1520 (620)	335 (305)
			1940 (780)	430 (390)
SHACKLETON TOWNSHIP				
0-3 (0-1)	Type A	60 (18)	425 (172)	94 (85)
3-25 (1-8)	Type A	60 (18)	16,800 (6800)	3750 (3400)
			17,200 (7000)	3850 (3500)
0-3 (0-1)	Type B	60 (18)	390 (158)	86 (78)
3-25 (1-8)	Type B	60 (18)	23,600 (9600)	5200 (4700)
			24,000 (9700)	5300 (4800)
			41,000 (16 600)	9200 (8300)
SYDERE TOWNSHIP				
0-3 (0-1)	Type A	60 (18)	24 (10)	5 (4)
3-25 (1-8)	Type A	60 (18)	1690 (680)	375 (340)
			1710 (690)	380 (345)

TABLE 4 | TOTAL IDENTIFIED BEDROCK RESOURCES, SMOOTH ROCK FALLS AREA*

1 DRIFT THICKNESS Feet (Metres)	2 BEDROCK LITHOLOGY	3 QUARRIABLE THICKNESS Feet (Metres)	4 AREAL EXTENT Acres (Hectares)	5 ORIGINAL TONNAGE Millions of Tons (Tonnes)
0-3 (0-1)	Type B	60 (18)	2160 (870)	480 (435)
3-25 (1-8)	Type B	60 (18)	11,000 (4450)	2440 (2210)
			13,200 (5300)	2900 (2650)
			14,900 (6000)	3300 (3000)
WEBSTER TOWNSHIP				
0-3 (0-1)	Type A	60 (18)	350 (142)	78 (71)
3-25 (1-8)	Type A	60 (18)	370 (150)	82 (74)
			720 (290)	160 (145)
			84,000 (34 000)	18,800 (17 100)

* Bedrock resources of Type C rock (diabase dikes) are omitted on these tables because of the dikes small areal extent

TABLE 5 | QUARRIES, SMOOTH ROCK FALLS AREA

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 FACE HEIGHT Feet (Metres)	7 QUARRY STATUS
SHACKLETON TOWNSHIP						
1	SRF-21-2	E. Richard	14	10	8 (2)	
2	SRF-21-2	E. Richard	13, 14	10	10 (3)	
ALEXANDRA TOWNSHIP						
		– NONE –				
COLQUHOUN TOWNSHIP						
		– NONE –				
HAGGART TOWNSHIP						
		– NONE –				
KENDREY TOWNSHIP						
		– NONE –				
SYDERE TOWNSHIP						
		– NONE –				
WEBSTER TOWNSHIP						
		– NONE –				

TABLE 6 | SELECTED BEDROCK RESOURCE AREAS, SMOOTH ROCK FALLS AREA

1 DEPOSIT NO.	2 DEPTH OF OVERBURDEN Feet (Metres)	3 AREA Acres (Hectares)	4 CULTURAL SETBACKS Acres (Hectares)	5 EXTRACTED AREA Acres (Hectares)	6 AVAILABLE AREA Acres (Hectares)	7 ESTIMATED QUARRIABLE THICKNESS Feet (Metres)	8 AVAILABLE RESOURCES Millions of Tons (Tonnes)
KENDREY TOWNSHIP							
				– NONE –			
WEBSTER TOWNSHIP							
				– NONE –			
SYDERE TOWNSHIP							
1	0-3 (0-1)	2180 (880)	80 (32)	–	2100 (850)	60 (18)	465 (420)
HAGGART TOWNSHIP							
1	0-3 (0-1)	2170 (880)	10 (4)	–	2160 (870)	60 (18)	480 (435)
3	0-15 (0-5)	1040 (420)	380 (154)	–	660 (265)	60 (18)	146 (132)
		3200 (1300)	390 (158)		2800 (1130)		630 (570)
COLQUHOUN TOWNSHIP							
2	0-3 (0-1)	450 (182)	–	–	450 (182)	60 (18)	100 (91)
6	0-3 (0-1)	135 (55)	5 (2)	–	130 (53)	60 (18)	29 (26)
		580 (235)	5 (2)		580 (235)		129 (117)

TABLE 6 | SELECTED BEDROCK RESOURCE AREAS, SMOOTH ROCK FALLS AREA

1 DEPOSIT NO.	2 DEPTH OF OVERBURDEN Feet (Metres)	3 AREA Acres (Hectares)	4 CULTURAL SETBACKS Acres (Hectares)	5 EXTRACTED AREA Acres (Hectares)	6 AVAILABLE AREA Acres (Hectares)	7 ESTIMATED QUARRIABLE THICKNESS Feet (Metres)	8 AVAILABLE RESOURCES Millions of Tons (Tonnes)
SHACKLETON TOWNSHIP							
3	0-15 (0-5)	375 (152)	135 (55)	–	240 (97)	60 (18)	53 (48)
4a	0-3 (0-1)	300 (121)	50 (20)	10 (4)	240 (97)	60 (18)	53 (48)
4b	0-25 (0-8)	105 (42)	40 (16)	–	65 (26)	60 (18)	14 (13)
4c	0-3 (0-1)	560 (227)	65 (26)	–	495 (200)	60 (18)	110 (100)
5	0-3 (0-1)	445 (180)	10 (4)	–	435 (176)	60 (18)	96 (87)
7a	0-3 (0-1)	72 (29)	22 (9)	–	50 (20)	60 (18)	11 (10)
7b	0-3 (0-1)	250 (101)	30 (12)	–	220 (89)	60 (18)	49 (44)
		2110 (850)	350 (142)	10 (4)	1740 (700)		385 (350)
ALEXANDRA TOWNSHIP							
8	3-25 (1-8)	1970 (800)	370 (150)	–	1600 (650)	60 (18)	355 (320)
		10,000 (4050)	1200 (485)	10 (4)	8800 (3550)		1960 (1780)

TABLE 7 | SUMMARY OF TEST HOLE DATA, SMOOTH ROCK FALLS AREA

ALEXANDRA TOWNSHIP

Test Hole Number: AL-TH-7

Location: South-central part of township

Elevation: Approximately 750 feet (229 m) a.s.l.

Date: June 11, 1981

DEPTH Feet (metres)	DESCRIPTION
0-11 (0-3.4)	clay till (Cochrane till)

Test Hole Number: AL-TH-8

Location: Central part of township

Elevation: Approximately 700 feet (213 m) a.s.l.

Date: June 11, 1981

DEPTH Feet (metres)	DESCRIPTION
0-12 (0-3.7)	clay till (Cochrane till)

Test Hole Number: AL-TH-9

Location: Central part of township

Elevation: Approximately 700 feet (213 m) a.s.l.

Date: June 11, 1981

DEPTH Feet (metres)	DESCRIPTION
0-9 (0-2.7)	clay till (Cochrane till)

TABLE 7 | SUMMARY OF TEST HOLE DATA, SMOOTH ROCK FALLS AREA

COLQUHOUN TOWNSHIP

Test Hole Number: CO-TH-11

Location: Lot 27, Conc. 3

Elevation: Approximately 900 feet (275 m) a.s.l.

Date: June 12, 1981

DEPTH Feet (metres)	DESCRIPTION
0-2 (0-0.6)	fine to medium sand
2-4 (0.6-1.2)	fine stratified sand
4-6 (1.2-1.8)	silty very find sand to sandy silt; fining downward
6-9 (1.8-2.7)	very fine sand and varved silt and clay

HAGGART TOWNSHIP

Test Hole Number: HG-TH-1

Location: Lot 18, Conc. 9

Elevation: Approximately 780 feet (238 m) a.s.l.

Date: June 11, 1981

DEPTH Feet (metres)	DESCRIPTION
0-7 (0.2.1)	thin topsoil layer; clay till (Cochrane till)
7-13 (2.1-4.0)	well sorted clean medium sand

TABLE 7 | SUMMARY OF TEST HOLE DATA, SMOOTH ROCK FALLS AREA

Test Hole Number: HG-TH-2

Location: Lot 17, Conc. 9

Elevation: Approximately 780 feet (238 m) a.s.l.

Date: June 11, 1981

DEPTH Feet (metres)	DESCRIPTION
0-10 (0-3.0)	clay till (Cochrane till)

Test Hole Number: HG-TH-3

Location: Lot 18, Conc. 10

Elevation: Approximately 720 feet (219 m) a.s.l.

Date: June 11, 1981

DEPTH Feet (metres)	DESCRIPTION
0-6 (0-1.8)	coarse sand with fine gravel
6-14 (1.8-4.3)	stony coarse sand

Test Hole Number: HG-TH-4

Location: Lot 16, Conc. 10

Elevation: Approximately 750 feet (229 m) a.s.l.

Date: June 11, 1981

DEPTH Feet (metres)	DESCRIPTION
0-13 (0-4.0)	clay till (Cochrane till); water table at 11 feet (3.4 m)

TABLE 7 | SUMMARY OF TEST HOLE DATA, SMOOTH ROCK FALLS AREA

Test Hole Number: HG-TH-5

Location: Lot 16, Conc. 10

Elevation: Approximately 750 feet (229 m) a.s.l.

Date: June 11, 1981

DEPTH Feet (metres)	DESCRIPTION
0-12 (0-3.7)	clay till (Cochrane till)

Test Hole Number: HG-TH-6

Location: Lot 19, Conc. 12

Elevation: Approximately 750 feet (229 m) a.s.l.

Date: June 11, 1981

DEPTH Feet (metres)	DESCRIPTION
0-3 (0-0.9)	coarse sand; some gravel

Test Hole Number: HG-TH-12

Location: Lot 19, Conc. 12

Elevation: Approximately 750 feet (229 m) a.s.l.

Date: August 4, 1981

DEPTH Feet (metres)	DESCRIPTION
0-5 (0-1.5)	coarse sand with some fine gravel
5-10 (1.5-3.0)	coarse sand and fine gravel
10-15 (3.0-4.6)	fine to coarse sand with some gravel
15-20 (4.6-6.1)	coarse sand
20 (6.1)	auger grinding, probably gravel; no sample

TABLE 7 | SUMMARY OF TEST HOLE DATA, SMOOTH ROCK FALLS AREA

Test Hole Number: HG-TH-13

Location: Lot 19, Conc. 10

Elevation: Approximately 780 feet (238 m) a.s.l.

Date: August 4, 1981

DEPTH Feet (metres)	DESCRIPTION
0-15 (0-4.6)	clay till (Cochrane till) some coarse gravel
15-40 (4.6-12.2)	varved clay
40-50 (12.2-15.2)	silty very fine sand
50-60 (15.2-18.3)	fine sand

Test Hole Number: HG-TH-14

Location: Lot 20, Conc. 5

Elevation: Approximately 800 feet (244 m) a.s.l.

Date: August 6, 1981

DEPTH Feet (metres)	DESCRIPTION
0-5 (0-1.5)	medium to coarse sand and fine gravel
5-10 (1.5-3.0)	clay over stratified silt and fine sand
10-15 (3.0-4.6)	fine to coarse sand; silty fine sand
15-35 (4.6-10.7)	silt to fine sand
35-40 (10.7-12.2)	very fine to fine sand

TABLE 7 | SUMMARY OF TEST HOLE DATA, SMOOTH ROCK FALLS AREA

SYDERE TOWNSHIP

Test Hole Number: SY-TH-10

Location: North-central part of township

Elevation: Approximately 1000 feet (305 m) a.s.l.

Date: June 12, 1981

DEPTH Feet (metres)	DESCRIPTION
0-2 (0-0.6)	gravel and sand; clast supported
2-8 (0.6-2.4)	layered gravel and sand
8-12 (2.4-3.7)	coarse sand
12-14 (3.7-4.3)	coarse sand, some stones
14-16 (4.3-4.9)	clay till; bedrock

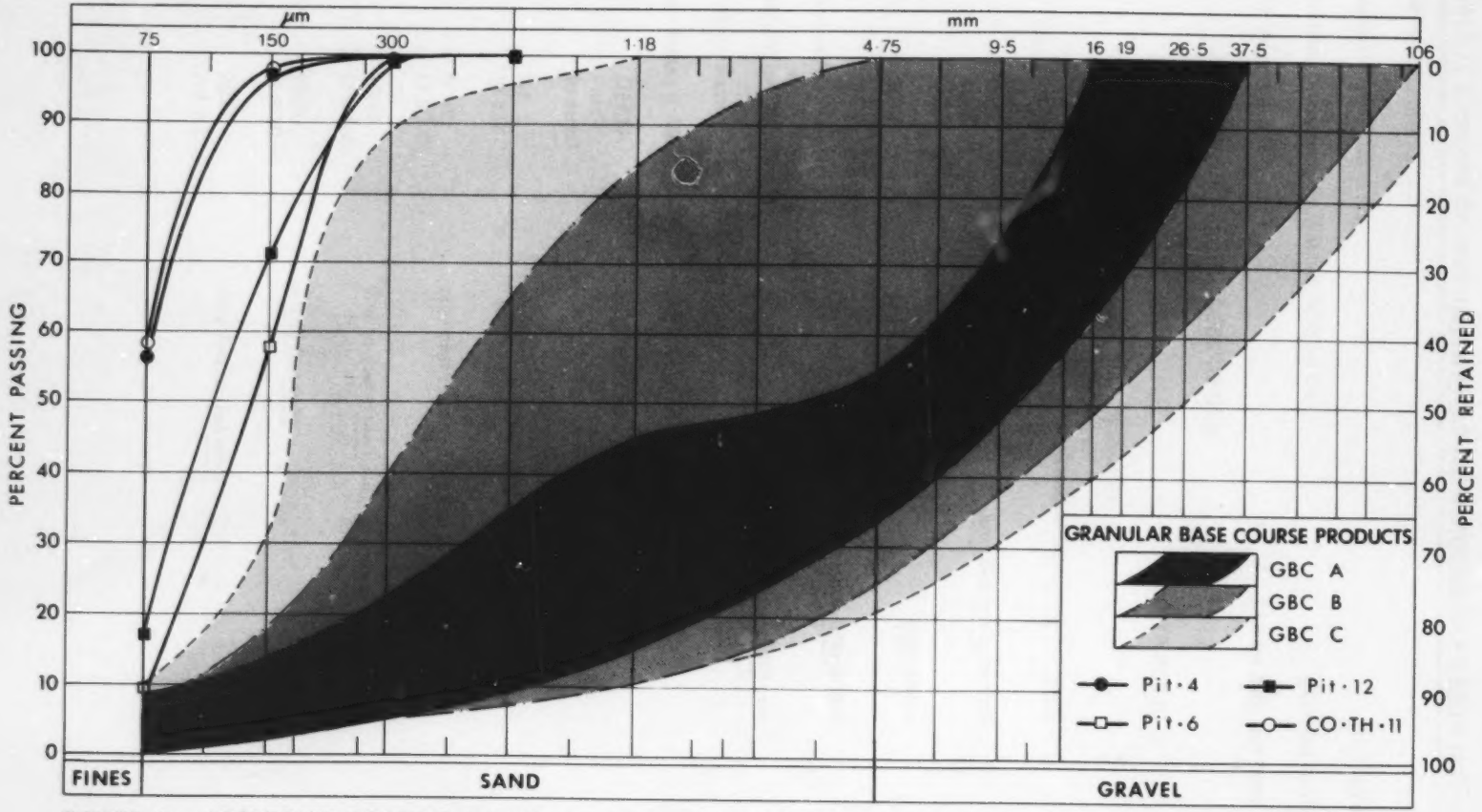


FIGURE 2: AGGREGATE GRADING CURVES, COLQUHOUN, KENDREY and SHACKLETON TOWNSHIPS;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

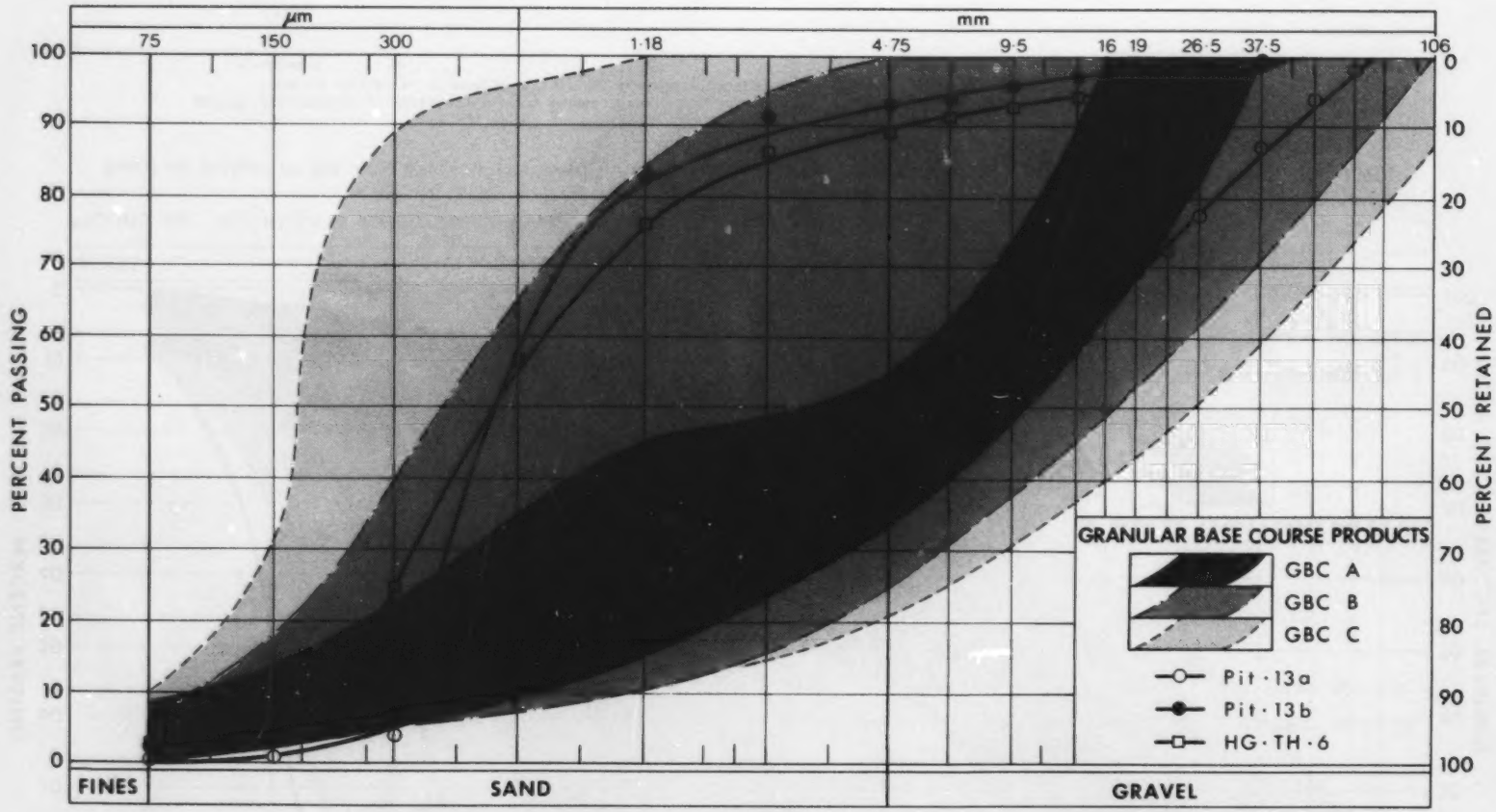


FIGURE 3a: AGGREGATE GRADING CURVES, HAGGART TOWNSHIP;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

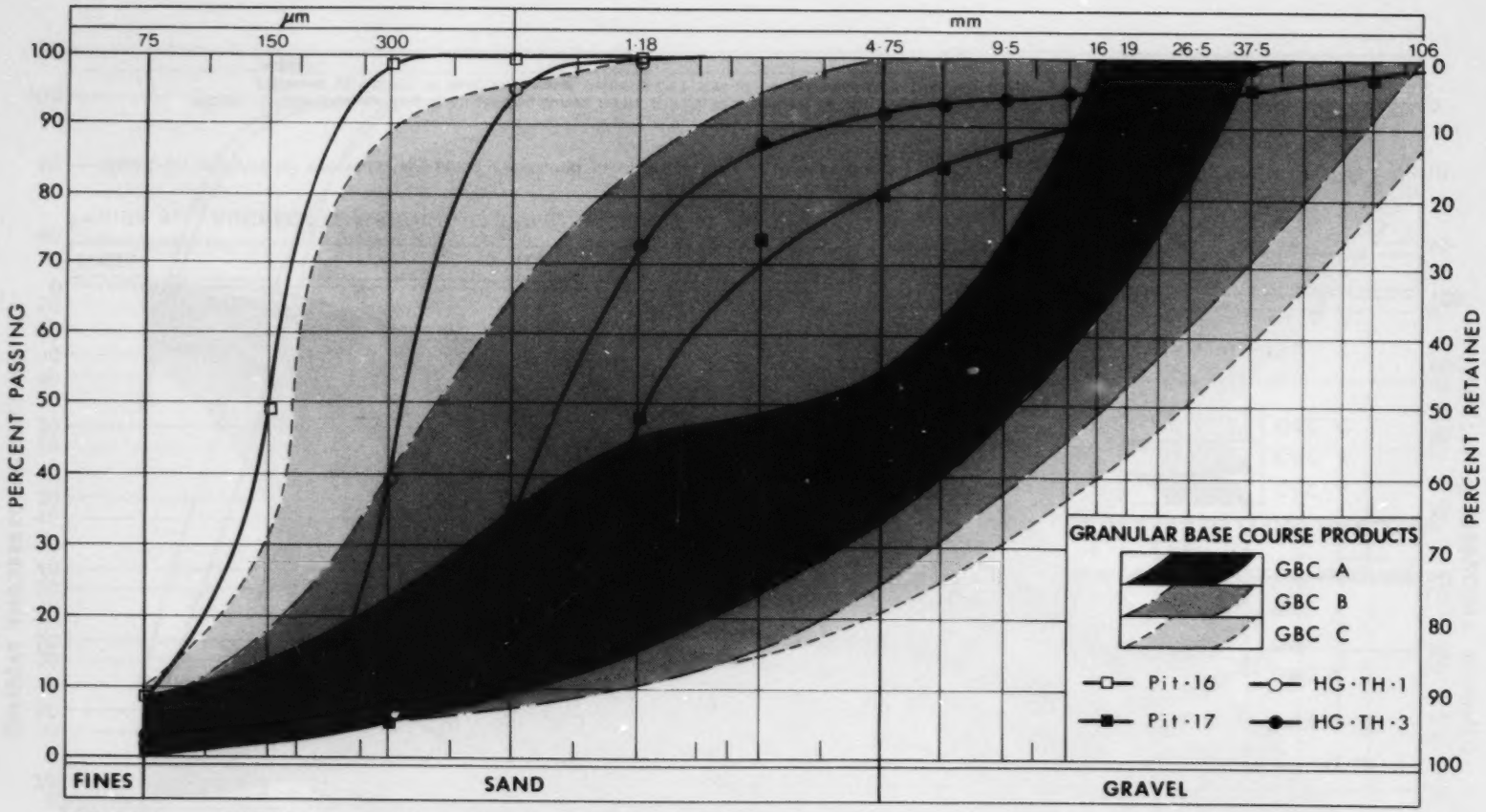


FIGURE 3b: AGGREGATE GRADING CURVES, HAGGART TOWNSHIP;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

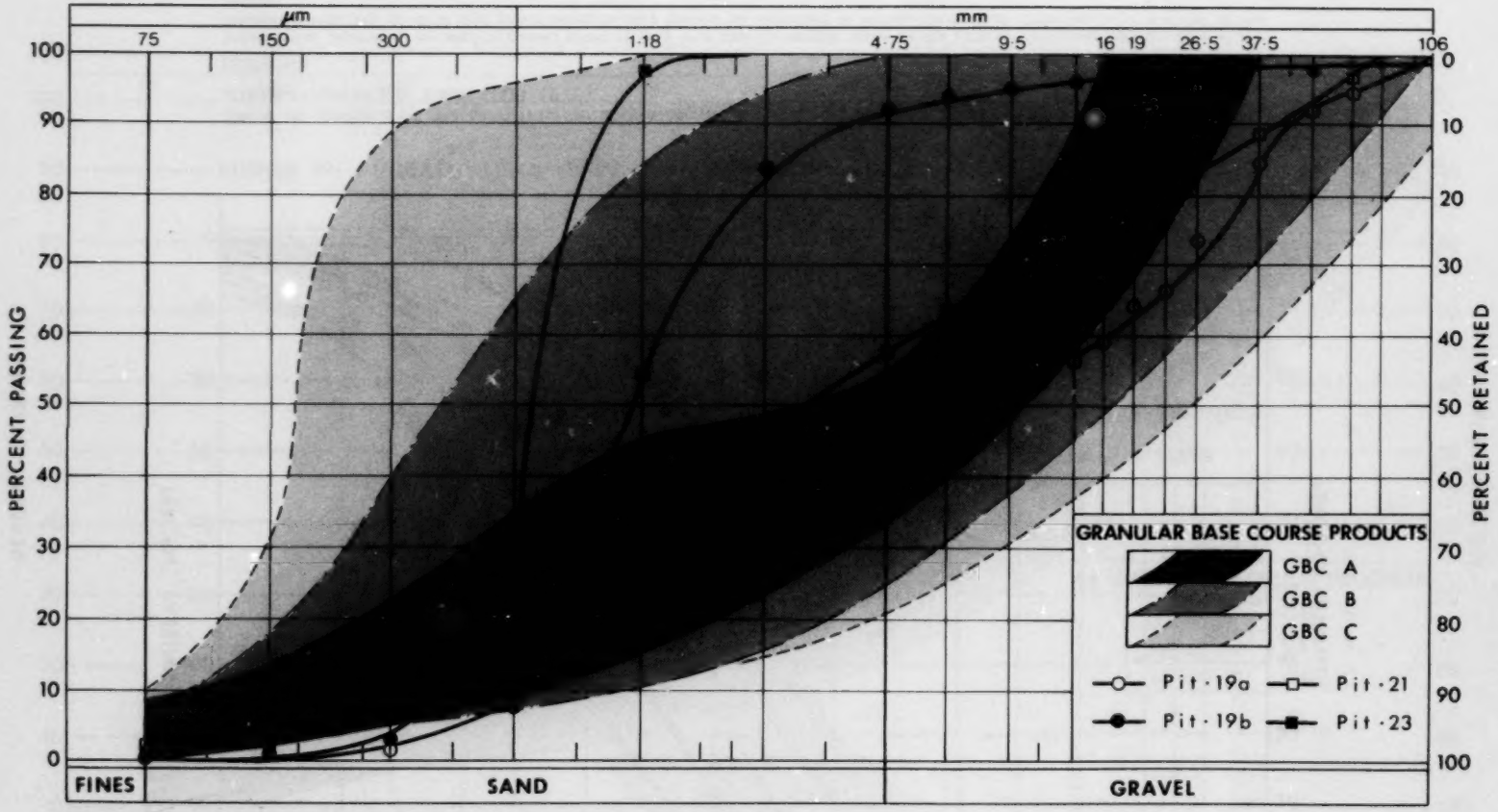


FIGURE 3c: AGGREGATE GRADING CURVES, HAGGART TOWNSHIP;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

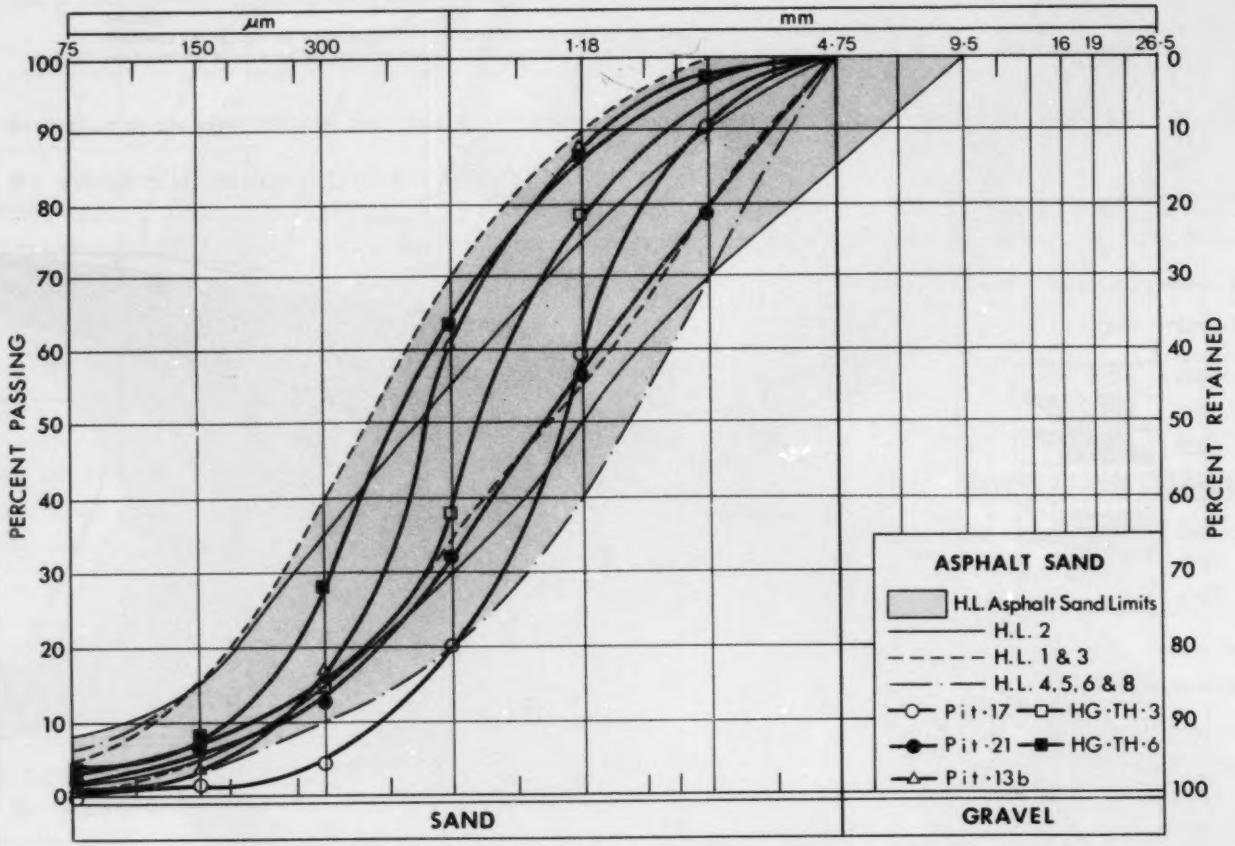


FIGURE 3d: AGGREGATE GRADING CURVES, HAGGART TOWNSHIP;

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1003, 1979).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

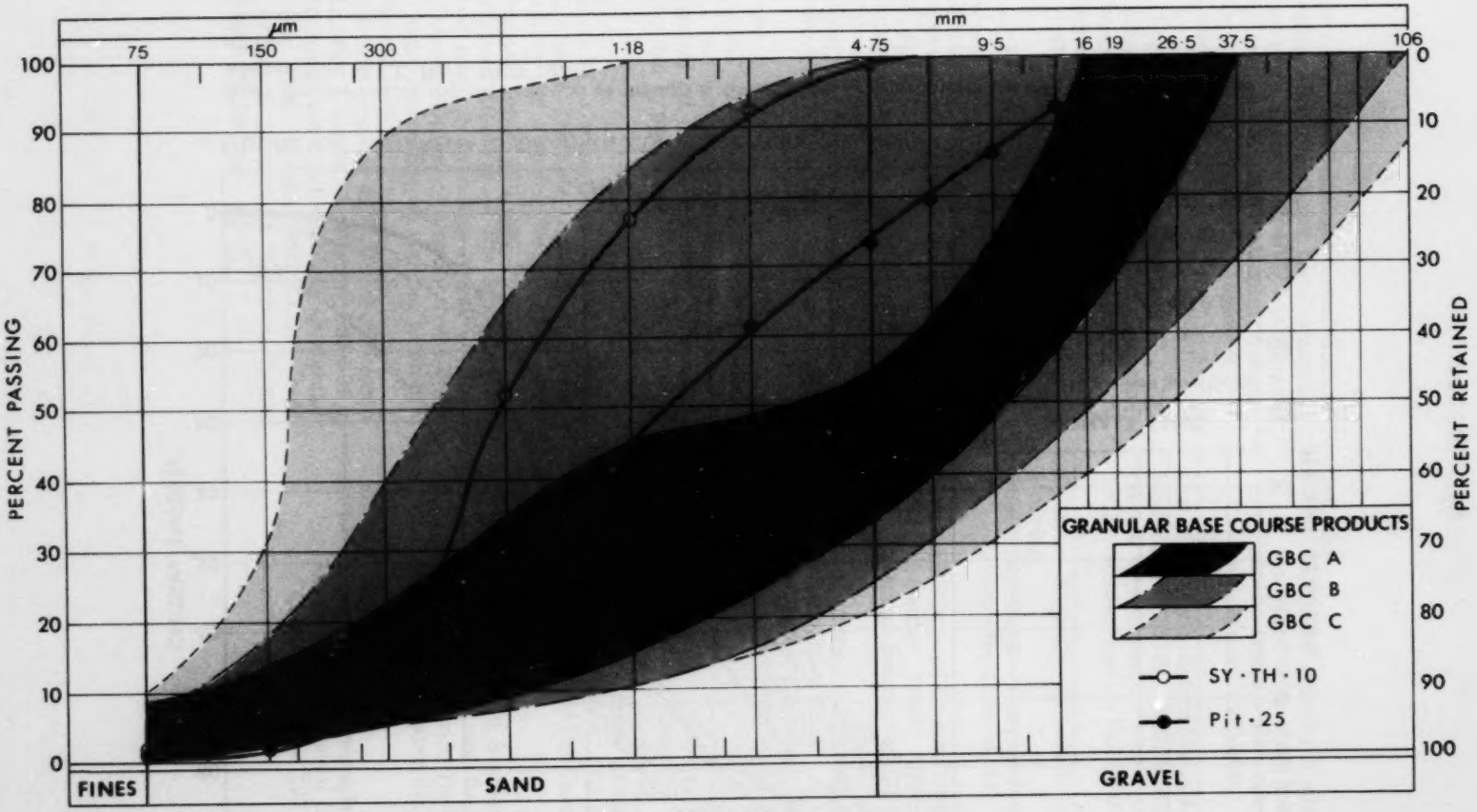


FIGURE 4a: AGGREGATE GRADING CURVES, SYDERE TOWNSHIP;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

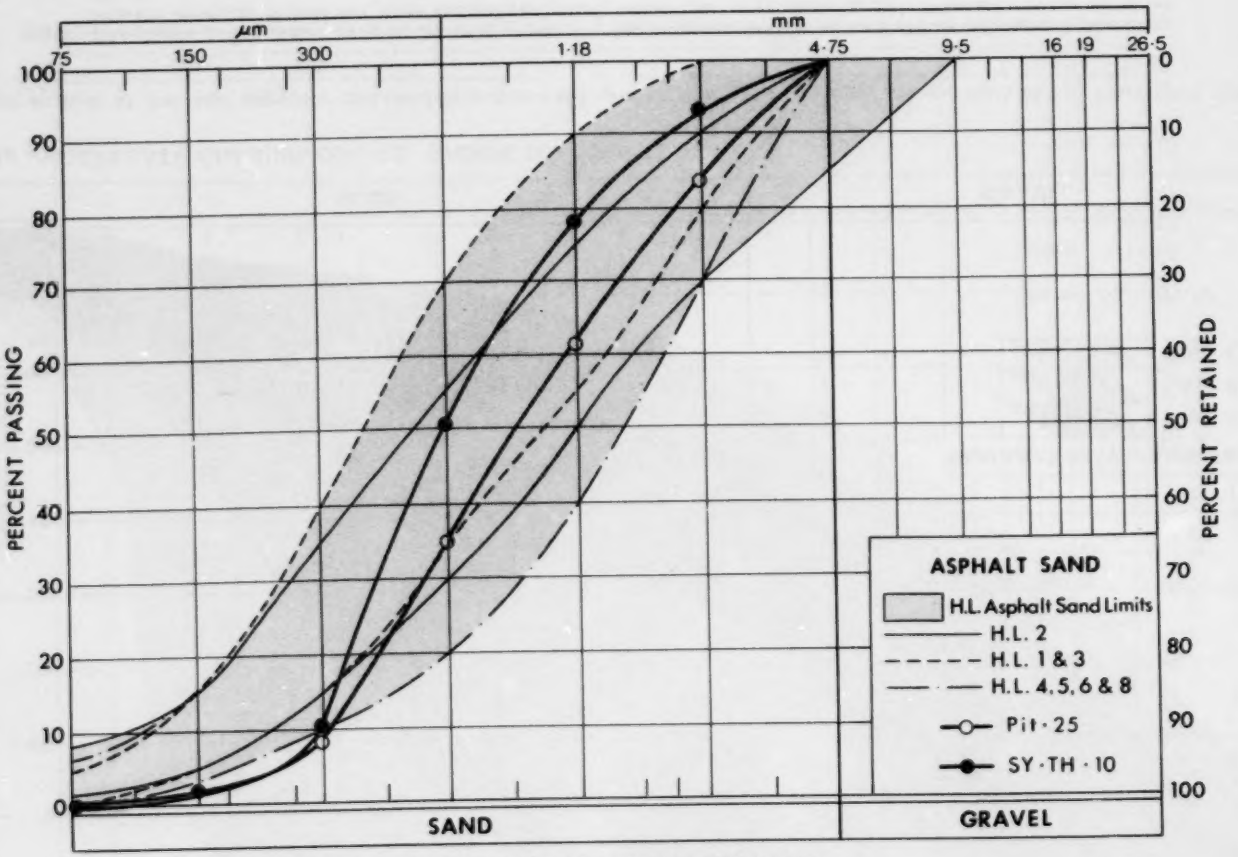


FIGURE 4b: AGGREGATE GRADING CURVES, SYDERE TOWNSHIP;

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1003, 1979).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

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APPENDIX B - GLOSSARY

ABRASION RESISTANCE

Tests such as the Los Angeles Abrasion Test are used to measure the ability of aggregate to resist crushing and pulverizing under conditions similar to those encountered in processing and use. Measuring resistance is an important component in the evaluation of the quality and prospective uses of aggregate. Hard, durable material is preferred for road building.

ABSORPTION CAPACITY

Related to the porosity of the rock types of which an aggregate is composed. Porous rocks are subject to disintegration when absorbed liquids freeze and thaw, thus decreasing the strength of the aggregate.

AGGREGATE

Any hard, inert, construction material (sand, gravel, shells, slag, crushed stone or other mineral material) used for mixing in various-sized fragments with a cement or bituminous material to form concrete, mortar, etc., or used alone for road building or other construction. Synonyms include mineral aggregate and granular material.

ALKALI-AGGREGATE REACTION

A chemical reaction between the alkalis of portland cement and certain minerals found in rocks used for aggregate. Alkali-aggregate reactions are undesirable because they can cause expansion and cracking of concrete. Although perfectly suitable for building stone and asphalt applications, alkali-reactive aggregates should be avoided for structural concrete uses.

BLENDING

Required in cases of extreme coarseness, fineness, or other irregularities in the gradation of unprocessed aggregate. Blending is done with approved sand-sized aggregate in order to satisfy the gradation requirements of the material.

CLAST

An individual constituent, grain, or fragment of a sediment or rock, produced by the mechanical weathering of a larger rock mass. Synonyms include particle and fragment.

CRUSHABLE AGGREGATE

Unprocessed gravel containing a minimum of 35 percent coarse aggregate larger than the No. 4 sieve (4.75 mm) as well as a minimum of 20 percent greater than the 26.5 mm sieve.

DELETERIOUS LITHOLOGY

A general term used to designate those rock types which are chemically or physically unsuited for use as construction or road-building aggregates. Such lithologies as chert, shale, siltstone, and sandstone may deteriorate rapidly when exposed to traffic and other environmental conditions. Similarly, highly weathered, very porous and friable rock can restrict the quality of the aggregate.

DOLOSTONE

A carbonate sedimentary rock consisting chiefly of the mineral dolomite and containing relatively little calcite (dolostone is also known as dolomite).

DRIFT

A general term for all unconsolidated rock debris transported from one place and deposited in another; distinguished from underlying bedrock. In North America, glacial activity has been the dominant mode of transport and deposition of drift. Synonyms include overburden and surficial deposit.

DRUMLIN

A low, smoothly rounded, elongated hill, mound, or ridge composed of glacial materials. These landforms were deposited beneath an advancing ice sheet, and were shaped by its flow.

EOLIAN

Pertaining to the wind, especially with respect to landforms whose constituents were transported and deposited by wind activity. Sand dunes are an example of an eolian landform.

FINES

A general term used to describe the size fraction of an aggregate which passes (is finer than) the No. 200 mesh screen (0.075 mm). Also described informally as "dirt", these particles are in the silt and clay size range.

GNEISS

A coarse-textured metamorphic rock with the minerals arranged in parallel streaks or bands, but lacking schistosity. Gneiss is relatively rich in feldspar. Other common minerals found in this rock include quartz, mica, amphibole and garnet.

GRADATION

The proportion of material of each particle size, or the frequency distribution of the various sizes which constitute a sediment. The strength, durability, permeability and stability of an aggregate depend to a great extent on its gradation. The size limits for different particles are as follows:

Boulders	more than 200 mm
Cobbles	75-200 mm
Coarse Gravel	26.5-75 mm
Fine Gravel	4.75-26.5 mm
Coarse Sand	2-4.75 mm
Medium Sand	0.425-2 mm
Fine Sand	0.075-0.425 mm
Silt, Clay	less than 0.075 mm

GRANITE

Is a coarse-grained light coloured rock that ordinarily has an even texture and is composed of quartz, and feldspar with either mica, hornblende or both.

GRANULAR BASE COURSE

Components of the pavement structure of a road, which are placed on the subgrade and are designed to provide strength, stability, and drainage, as well as support for surfacing materials. Several types have been defined: Granular Base Course A consists of crushed and processed aggregate and has relatively stringent quality standards in comparison to Granular Base Course B and C which are usually pit-run or other unprocessed aggregate.

HOT-LAID (OR ASPHALTIC) AGGREGATE

Bituminous, cemented aggregates used in the construction of pavements either as surface or bearing course (H.L. 1, 3, and 4), or as binder course (H.L. 2, 6, and 8) used to bind the surface course to the underlying granular base course.

LITHOLOGY

The description of rocks on the basis of such characteristics as color, structure, mineralogic composition, and grain size. Generally, the description of the physical character of a rock.

MAGNESIUM SULPHATE SOUNDNESS TEST

This test is designed to simulate the action of freezing and thawing on aggregates. Those aggregates which are susceptible will usually break down and give high losses in this test.

MELTWATER CHANNEL

A drainage way, usually terraced, produced by water flowing away from a melting glacier margin.

PETROGRAPHIC EXAMINATION

An aggregate quality test based on known field performance of various rock types. The test result is a Petrographic Number (P.N.). The higher the P.N. the lower the quality of aggregate.

PLEISTOCENE

An epoch of the recent geological past including the time from approximately 1.8 million years ago to 7000 years ago. Much of the Pleistocene was characterized by extensive glacial activity and is popularly referred to as the "Great Ice Age".

POSSIBLE RESOURCE

Estimates of mineral aggregate material based largely on broad knowledge of the geologic character of the deposit and for which there are few, if any, samples or measurements. The estimates are based on assumed continuity or repetition for which there are reasonable geological indications.

PRECAMBRIAN

The earliest geologic period extending from the consolidation of the earth's crust to the beginning of the Cambrian.

SHALE

A fine-grained, sedimentary rock formed by the consolidation of clay, silt, or mud and characterized by well developed bedding planes, along which the rock breaks readily into thin layers. The term shale is also commonly used for fissile claystone, siltstone, and mudstone.

SOUNDNESS

The ability of the components of an aggregate to withstand the effects of various weathering processes and agents. Unsound lithologies are subject to disintegration caused by the expansion of absorbed solutions. This may seriously impair the performance of road-building and construction aggregates.

TILL

Unsorted and unstratified rock debris, deposited directly by glaciers, and ranging in size from clay to large boulders.

WISCONSINAN

Pertaining to the last glacial stage of the Pleistocene Epoch in North America. It began approximately 100 000 years ago and ended approximately 7000 years ago. The glacial deposits and landforms of Ontario are predominantly the result of glacial activity during the Wisconsinan Stage.

APPENDIX C - GEOLOGY OF SAND AND GRAVEL DEPOSITS

The type, distribution, and extent of sand and gravel deposits in Ontario are the result of extensive glacial and glacially influenced activity in Wisconsinan time during the Pleistocene Epoch, approximately 100 000 to 7000 years ago. The deposit types reflect the different depositional environments that existed during the melting and retreat of the continental ice masses, and they can readily be differentiated on the basis of their morphology, structure, and texture. The deposit types are described below.

GLACIOFLUVIAL DEPOSITS

These deposits can be divided into two broad categories: those that were formed in contact with (or in close proximity to) glacial ice, and those that were deposited by meltwaters carrying materials beyond the ice margin.

ICE-CONTACT TERRACES (ICT)

These are glaciofluvial features deposited between the glacial margin and a confining topographic high, such as the side of a valley. The structure of the deposits may be similar to that of outwash deposits, but in most cases the sorting and grading of the material is more variable and the bedding is discontinuous due to extensive slumping. The probability of locating large amounts of crushable aggregate is moderate, and extraction may be expensive due to the variability of the deposits both in terms of quality and grain size distribution.

KAMES (K)

Kames are defined as mounds of poorly sorted sand and gravel deposited by meltwater in depressions or fissures on the ice surface or at its margin. During glacial retreat, the melting of supporting ice causes collapse of the deposits, producing internal structures characterized by bedding discontinuities. The deposits consist mainly of irregularly bedded and crossbedded, poorly sorted sand and gravel. The present forms of the deposits include single mounds, linear ridges (crevasse fillings) or complex groups of landforms. The latter are occasionally described as "undifferentiated ice-contact stratified drift" (IC) when detailed subsurface information is unavailable. Since kames commonly contain large amounts of fine-grained material and are characterized by considerable variability, there is generally a low to moderate probability of discovering large amounts of good quality, crushable aggregate. Extractive problems encountered in these deposits are mainly the excessive variability of the aggregate and the presence of excess fines (silt- and clay-sized particles).

ESKERS (E)

Eskers are narrow, sinuous ridges of sand and gravel deposited by meltwaters flowing in tunnels within or at the base of glaciers, or in channels on the ice surface. Eskers vary greatly in size. Many, though not all eskers consist of a central core of poorly sorted and stratified gravel characterized by a wide range in grain size. The core material is often draped on its flanks by better sorted and stratified sand and gravel. The deposits have a high probability of containing a large proportion of crushable aggregate, and since they are generally built above the surrounding ground surface, are convenient extraction sites. For these reasons esker deposits have been traditional aggregate sources throughout Ontario, and are significant components of the total resources of many areas.

Some planning constraints and opportunities are inherent in the nature of the deposits. Because of their linear nature, the deposits commonly extend across several property boundaries leading to unorganized extractive development at numerous small pits. On the other hand, because of their form, eskers can be easily and inexpensively extracted and are amenable to rehabilitation and sequential land use.

UNDIFFERENTIATED ICE-CONTACT STRATIFIED DRIFT (IC)

This designation may include deposits from several ice-contact, depositional environments which usually form extensive, complex landforms. It is not feasible to identify individual areas of coarse-grained material within such deposits due to their lack of continuity and

grain size variability. They are given a qualitative rating based on existing pit and other subsurface data.

OUTWASH (OW)

Outwash deposits consist of sand and gravel laid down by meltwaters beyond the margin of the glacier. The deposits occur as sheets or as terraced valley fills (valley trains) and may be very large in extent and thickness. Well developed outwash deposits have good horizontal bedding and are uniform in grain size distribution. Outwash deposited near the glacier's margin is much more variable in texture and structure. The probability of locating useful crushable aggregates in outwash deposits is moderate to high depending on how much information on size, distribution and thickness is available.

ALLUVIUM (AL)

Alluvium is a general term for clay, silt, sand, gravel, or similar unconsolidated material deposited during postglacial time by a stream as sorted or semi-sorted sediment, on its bed or on its floodplain. The probability of locating large amounts of crushable aggregate in alluvial deposits is low, and it has generally low value due to the presence of excess silt- and clay-sized material. There are no large postglacial alluvium deposits in Ontario.

GLACIOLACUSTRINE DEPOSITS

GLACIOLACUSTRINE BEACH DEPOSITS (LB)

These are relatively narrow, linear features formed by wave action at the shores of glacial lakes that existed at various times during the deglaciation of Ontario. Well developed lacustrine beaches are usually less than 20 feet (6 m) thick. The aggregate is well sorted and stratified and sand-sized material commonly predominates. The composition and size distribution of the deposit depends on the nature of the underlying material. The probability of obtaining crushable aggregate is high when the material is developed from coarse-grained materials such as a stony till, and low when developed from fine-grained materials. Beaches are relatively narrow, linear deposits, so that extractive operations are often numerous and extensive.

GLACIOLACUSTRINE DELTAS (LD)

These features were formed where streams or rivers of glacial meltwater flowed into lakes and deposited their suspended sediment. In Ontario such deposits tend to consist mainly of sand and abundant silt. However, in near-ice and ice-contact positions, coarse material may be present. Although deltaic deposits may be large, the probability of obtaining coarse material is generally low.

GLACIOLACUSTRINE PLAIN (LP)

The nearly level surface marking the floor of an extinct glacial lake. The sediments which form the plain are predominantly fine to medium sand, silt, and clay, and were deposited in relatively deep water. Lacustrine deposits are generally of low value as aggregate sources due to their fine grain size and lack of crushable material. In some aggregate-poor areas, lacustrine deposits may constitute valuable sources of fill and some granular base course aggregate.

GLACIAL DEPOSITS

END MORAINES (EM)

These are belts of glacial drift deposited at, and parallel to, glacier margins. They commonly consist of ice-contact stratified drift and in such instances are usually called kame moraines. Kame moraines commonly result from deposition between two glacial lobes (interlobate moraines). The probability of locating aggregates within such features is moderate to low. Exploration and development costs are high. Moraines may be very large and contain vast aggregate resources, but the location of the best areas within the moraine is usually poorly defined.

EOLIAN DEPOSITS

WINDBLOWN FORMS (WD)

Windblown deposits are those formed by the transport and deposition of sand by winds. The form of the deposits ranges from extensive, thin layers to well developed linear and crescentic ridges known as dunes. Most windblown deposits in Ontario are derived from, and deposited on, pre-existing lacustrine sand plain deposits. Windblown sediments are almost

invariably composed of fine to coarse sand and are usually well sorted. The probability of locating crushable aggregate in windblown deposits is very low.

APPENDIX D - GEOLOGY OF BEDROCK DEPOSITS
(Modified after Bennett et al. 1967a)

ROCK TYPE A - MIGMATITE-METASEDIMENTARY-METAVOLCANIC COMPLEX (EARLY PRECAMBRIAN):

These rocks exhibit a wide range of composition and metamorphic structure. Pre-existing rocks were deformed and recrystallized forming biotite-quartz-feldspar, hornblende-quartz-feldspar and granitic gneisses. Quartz-mica schist and lit-par-lit granite are also present in the complex.

ROCK TYPE B - FELSIC INTRUSIVE ROCKS (EARLY PRECAMBRIAN):

These rocks occur as batholithic intrusions and satellite stocks in the gneissic complex. The rocks range from granite to quartz monzonite to granodiorite. The texture varies from fine grained to pegmatitic and both massive and foliated varieties occur.

ROCK TYPE C - DIABASE DIKES (EARLY TO LATE PRECAMBRIAN):

These rocks are fine to coarse grained and gabbroic to diabasic textured.